THE NATURE OF SCIENTIFIC COMMUNITY IN INDIA
A STUDY OF UNIVERSITY PHYSICISTS

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PREMA RAJAGOPALAN

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To
the memory of
my father

CERTIFICATE

It is certified that the work contained in the thesis entitled "Nature of Scientific Community in India: A Study of University Physicists" by Prema Rajagopalan has been carried out under our supervision and that the work has not been submitted elsewhere for a degree.

August 1990

Prof. K.N. Sharma
Department of Humanities and Social Sciences
Indian Institute of Technology
KANPUR

Dr. V. K. Jairath
Department of Sociology
Delhi School of Economics
Delhi University
DELHI

SYNOPSIS

Name of student : Prema Rajagopalan Roll No : 8410066

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The present study attempts to understand the nature of fragmentation of the scientific community in India which occupies a peripheral status in world science. The focus is not on any paradigm governed 'community' or network of scattered individual scientists in a narrowly defined research area, but fragmentation at the institutional level.

Within this scientific periphery, specialised research institutions are generally believed to form the centre in relation to universities. The latter in turn extend the centre-periphery chain through a wide variety of institutions. Our study limits itself to an understanding of the fragmentary nature of the scientific community in Indian universities. Physicists have been chosen for this purpose as physics is among the oldest science disciplines.

The professional linkages that characterise 'communities' of scientists in advanced countries may not be as significant in peripheral science. Our main interest therefore is the informal academic and extra-academic linkages among scientists. Our study has brought forth aspects of 'visibility' and 'power' peculiar to peripheral science. The diversity within the framework of university science enables us to construct within the periphery two polarities:

'good science' and 'bad science'. However, several positive features of 'bad science' emerge from this analysis, and our study recovers interesting particularities in the neglected peripheral universities which form the bulk of training institutions in science in India.

The study is based on seven departments of physics from four different types of universities, scattered in different regions of the country. These are: M.S. University of Baroda -- a unitary/state type, university of Madras -- a affiliating/state kind, Indian Institute of Science, Bangalore -- a 'deemed to be university' and Delhi University -- a central university. In all, 87 physicists were interviewed at length from two departments of Baroda, three departments of Madras and one each from Bangalore and Delhi.

The specific objectives of the study are to (i) look into the formal and informal research interactions of scientists (ii) examine the role of academic and extra academic linkages of scientists with the rest of the scientific community in the 'doing of science' and (iii) explicate how these linkages determine the visibility of scientists. An interview schedule was used as the main tool of data collection. Primary data were collected on (1) educational background and career profile of scientists (2) their teaching duties, research interests and research productivity (3) patterns of recruitment, incentives offered by institutions, criteria for promotion (4) awards, rewards obtained by scientists (5) membership of respondents of academic associations, scientific societies and other such committees.

Chapter I discusses the relevant literature on scientific community in the west, scientifically peripheral countries and India and specifies the problem. Chapter II provides a historical background of the institutional development of modern science in

India. Chapter III provides specific historical details on the establishment of the selected departments and the socio-political milieu in which they are located. Chapter IV discusses the teaching duties, infrastructural facilities and system of headship in the departments. Chapter V analyses the research interests of respondents and patterns of productivity. Chapter VI investigates the internal and external research interaction in terms of both formal established communication patterns and informal ones. Chapter VII relates the recognition of scientists to their 'visibility' within and outside the scientific community and the eventual 'power' they wield. Chapter VIII presents the conclusions.

In our findings, the Molecular Biophysics Unit (MBU) of Bangalore and physics department of M.S. University Baroda (henceforth Baroda X) represent the two extremes in the Indian community of physicists. The other five departments lie somewhere inbetween in the hierarchy, but do not seem to follow a rigid ranking system.

The MBU scientists are self-sufficient; work in an essentially research oriented department, have won national awards, are members of key national level committees of science and have gained 'visibility' through their research. The Baroda X physicists belong to an essentially teaching oriented department, have won no national awards, are members of committees at the local and regional levels and although they may be considered 'least visible' nationally, they are 'highly visible' within the local academic and non-academic environment. However, both the departments may seem isolated from the rest of the scientific community of the country.

The nature of professional linkages with the rest of the scientific community suggests interesting characteristics. MBU

presents itself as a highly competitive team at the international level. They have strong internal interaction and directed external interaction within the country (generally non-reciprocal) and outside the country. Their contacts with scientists working on similar problems within the country is irregular but with scientists in laboratories of advanced western countries is directed, specific, reciprocal and often yields joint publications.

The Baroda X physicists have limited research interests, low internal interaction as their interests are different, their external contacts are diffuse and sporadic and depend on individual initiatives. Their research productivity is low and the research does not appear in international journals of repute. They may represent all features of doing 'bad science' but perform very important functions at the local level. They regularly write text-books and books on general science and physics in the local language Gujarati, emphasize problems of teaching in their local conventions and have links with the wealthy patrons of the university. They are actively engaged in popularising science by involving themselves in people science movements. Thus, they fulfil the obligations of a state university by catering to the needs of the local community and acquire power and 'visibility' in a different sense at the regional level.

These two opposites, isolated in their own ways, characterise the fragmented nature of scientific community. They, however do relate in some ways. The large number of state universities like Baroda X systematically train students and provide the necessary talent for the advanced research institutes, which appropriate the talent, but return very little to these universities. Further, science policy, propogating 'Big Science' does not recognize the important role of scientists in peripheral universities.

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Prema Rajagopalan

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CHAPTER I

SCIENTIFIC COMMUNITY STUDIES: A REVIEW

The present study is an attempt to understand the nature of fragmentation of the scientific community in India which is assigned a peripheral status in world science. The point of departure for the study is not any paradigm-governed 'community' or network of scattered individual scientists in a narrowly defined research area or a specific discipline. The focus, instead is on fragmentation among scientists in the background of their institutional affiliations.

In the Indian context, specialised research institutions are generally understood to form the centre in relation to universities which constitute the periphery. The latter,in turn, extend the centre-periphery chain through a wide diversity in the Indian institutional setting. Our study is concerned with the fragmentary nature of university science alone and is confined to the physicists. They are from seven different departments of physics belonging to four universities, each of a distinct type, and scattered in different regions of the country.

Our main interest here lies, not in paradigm - governed formal professional linkages which may not be as significant in peripheral science as in the 'communities' of scientists in advanced western countries, but in informal academic and extra-academic linkages. Such a view leads us to aspects of

'visibility' and 'power' peculiar to peripheral science. The diversity within the universities in India, has enabled us to construct the polar opposites of 'good science' and 'bad science' in a periphery. However, some interesting positive features of 'bad science' emerge from the analysis. Our study thus recovers interesting potentialities in the completely neglected and much maligned peripheral universities which form the bulk of the training institutions of science in India.

The three major frameworks in sociology of science with respect to the study of scientific community are discussed in Section I of this chapter. It is followed in Section II by an evaluation of the scanty literature on the study of scientific community in the peripheral countries. Section III defines the objectives of our study, based on our perception of deficiencies and gaps in the literature on studies on the scientific community in India.

SECTION I

1.1 MERTON AND FOLLOWERS

Merton and his followers have studied the scientific community within the system of 'norms' of science. The four norms pointed out by him are universalism, communism, disinterestedness and organised scepticism. By universalism,

Merton means: "The acceptance or rejection of claims entering the lists of science is not to depend on the personal or social attributes of their protagonist; his race, nationality, religion, class and personal qualities are as such irrelevant. Objectivity precludes particularism. The circumstance that scientifically verified formulations refer to objective sequences and correlations militates against all efforts to impose particularistic criteria of validity" (1981; 607).

Communism, "in the non-technical and extended sense of common ownership of goods, is a second integral element of the scientific ethos. The substantive findings of science are a product of social collaboration and are assigned to the community. They constitute a common heritage in which the equity of the individual producer is severely limited. ... The scientist's claim to 'his' intellectual 'property' is limited to that of recognition and esteem which, if the institution functions with a modicum of efficiency, is roughly commensurate with the significance of the increments brought to the common fund of knowledge" (1981: 610).

Science, Merton states "as is the case with the professions in general, includes disinterestedness as a basic institutional element.... A passion for knowledge, idle curiosity, altruistic concern with the benefit to humanity and a host of other special motives have been attributed to the scientist... The demand for disinterestedness has a firm basis in the public and testable

character of science and this circumstance, it may be supposed, has contributed to the integrity of men of science" (1981: 612-613).

"Organised scepticism is variously interrelated with the other elements of the scientific ethos. It is both a methodologic and an institutional mandate. The suspension of judgement until 'the facts are at hand' and the detached scrutiny of beliefs in terms of empirical and logical criteria have periodically involved science in conflict with other institutions" (1981: 614).

For Merton, "The institutional goal of science is the extensiion of certified knowledge. The technical methods employed towards this end provide the relevant definition of knowledge: empirically confirmed and logically consistent predictions" (1981: 606). Hence for the followers of Merton, all processes directed towards the achievement of this goal were of interest. Scientists' adherence to the above mentioned norms within and across specialisations/disciplines and within and across countries have been recurrent problems undertaken for research. The contribution of scientists mainly in terms of their research productivity, recognitions received in the form of citations and other rewards for their contribution constitute the main issues of inquiry.

Within this framework, studies on scientific community have focused on the social processes of communication, co-operation

and competition among scientists. Studies on communication mainly emphasize the structures and functions of communication. Questions relating to the randomness or directedness of communication have been raised. Diana Crane (1972: 45) in her attempt to understand the social organisation of research areas has constructed a sociogram (based on information from respondents regarding identity of scientists with whom they discuss research) to illustrate the sociometric choices of scientists. Based on this, she concludes that 60 percent of her sample scientists in mathematics are members of a single network. So is the case with 73 percent of rural sociologists who also form a part of her study.

Similarly, Mullins (1968) has shown that informal communication among the fifty biological scientists he studied form a discernible social structure. He has demonstrated that this social structure, characterised by network structures,is ordered by the culture of science, as represented by descriptions of research and the orientations underlying those decriptions.

These studies have attempted to analyse the structure of communication among scientists using published collaboration records. They have inferred that informal or personal communication which may or may not resemble formal communication (for example joint authorship of papers) are much more important for the cognitive growth of science. Thus a communication network that links groups of collaborators more informally than

formally is called an 'invisible college' (especially through leaders). These colleges are said to be effective for the transmission of information regarding research informally across the entire field (Crane, 1972: 35). Such studies have remained largely empirical and have not attempted to construct theories.

From studies on structures of communication, interest shifted to study co-operation among scientists, more popularly known as collaboration and team work. Co-authored papers provide the best indicator for analysing collaboration pattern among scientists. It has been sufficiently demonstrated by Price (1963) that there has been a consistent increase in the percentage of co-authored papers especially since world war II.

Hagstrom (1964) has vividly explained the modern concept of team work. The requirement of very specialised skills for certain types of research necessitates the coming together of scientists and technical professionals with varied skills, at times from varied disciplines too, in order to solve certain problems. This naturally results in more and more publications being co-authored by many as the nature of modern science is such that there is increasing specialisation on the one hand which also requires greater inter-disciplinary work on the other. Studies on research productivity have also gained importance in order to understand collaborative patterns among scientists [Price and Beaver, 1966]. Though they have indicated that collaboration is not a random process, yet little interest has

been shown to study the informal co-operation patterns among scientists systematically. Examples of such collaboration are the regular or frequent exchange of pre-prints and other forms of unpublished data and any other relevant information about on-going research among scientists. Studies of these kinds may reflect more on the collaborative nature of science and help to counter to some extent the view that all that is modern science is highly competitive.

The Mertonians believe that competition is inherent to science, as science demands originality. Studies in this area therefore include those on priorities in scientific discovery and on the consequences of competition on the scientific community. For Merton, science is a social institution with its own distinctive set of norms exerting moral responsibility on the scientists and the norms are invoked when they are felt to be violated. When the institution of science functions efficiently, recognition accrues to those who have contributed to the goal of science, namely, the extension of certified knowledge. In other words, recognition is an indicator to show that a scientist has lived up to his role and expectations. However, this recognition has to be awarded by his peers and hence the whole question of 'property rights' over the knowledge generated by a scientist largely depends on the recognition by his peers that he has done so. Merton therefore says that fights about priorities are not merely expressions of hot tempers, "they constitute responses to

what are taken to be violations of the institutional norms of intellectual property" (1957: 639).

Reif (1961), in line with Merton's ideas, has attempted in some detail to relate competition among scientists to the nature of modern scientific activity. He says that "the expansion of scientific activity since World War II has, however, significantly changed the conditions under which the scientist does his work" (1961: 1960). Scientists working in a single area of research have multiplied significantly and they work in industrial and governmental laboratories besides academic institutions. They generally are working not only on similar problems but also on similar lines of research. Another associated factor with modern science is the decrease in the time lag between advances in basic sciences and the related technological developments. In addition to these factors, modern science has also become an activity involving very high expenditure and due to its utilitarian dimensions, attracts funds from the general public too.

Such an expansion besides giving the scientist a more prominent social role, has also intensified the pressures under which he works. No more is it a quiet haven for scholarly activity, ideally suited to those of introverted temperament. The pure scientist, "like the businessman or lawyer, works in a social setting, and like them, he is subject to appreciable social and competitive pressures" [Reif, 1961:1957]. As the

social context in which a scientist receives training and work rates prestige very highly, competition among scientists is directed towards the acquisition of prestige. However, the forms of competition are determined by the nature of the relevant scientific discipline and the character of the institution in which he works.

Competition, however, both benefits the effective functioning of science on the one hand and also gives rise to less desirable results on the other. The prestige system helps to maintain high standards of accomplishment. Areas obtain high attention not merely because they are novel and different but also because of their potential to stimulate scientific contributions that have long term value. A subsidiary benefit is that research institutions vie with one another to get themselves well-equipped and better staffed in order to face the challenges of competition.

In contrast, the competitive atmosphere also subjects the individual scientist to considerable strain. He faces the conflict of values inherent to science such as careful and reflective research against the more selfish personal values of fast production in order to gain primacy which may result in shoddy work at times. Both Merton (1957) and Reif (1961) give ample illustrations of manifestations of such effects of competition in science.

The consequences of competition thus take several forms. Scientists may thus move out of certain research areas and direct their interests to less competitive ones, or they may work harder to be the first. They may also respond to competition by becoming secretive about their work or resort to devious means such as fraud (Merton 1957; Reif 1961; Hagstrom 1974). However, the followers of Merton believe that scientists strongly internalise the goal and norms of science and every member of the scientific community is a potential policeman and hence operates in a situation that minimises deviance from the norms of science. However, there have been studies to show the existence of counter-norms in science within the Mertonian framework (Mitroff, 1974).

Stratification in science arrived at primarily on the basis of the distribution of rewards, is one of the major concerns of the Mertonians. [Cole and Cole 1973; Gaston 1978; Zuckerman 1970]. However, studies on stratification in science remain confined to the study of quantitative productivity of scientists. As regards quality, they believe that citation takes care of this aspect which is considered to be one of the main indicators for the distribution of rewards. Essentially, these studies have analysed the distribution of rewards in the light of correlations between productivity and citation of scientists. Such studies do not fully explain the entire complex phenomenon of the distribution of rewards.

Most of the studies on the reward system have highlighted the functioning of the norm of universalism in science. Yet, there are a few which argue on the basis of sound evidence that particularistic characteristics (as opposed to universalistic) affect the productivity of scientists. For example, if one were to take into consideration differences in opportunities available to the scientists and regard the availability of opportunities as an important factor for initial success, then it would no longer follow that success indicates one's ability alone, or that it is only the intellectually capable scientists who move to the top of the scientific hierarchy.

Crane's (1965) study of 150 scientists (biologists, psychologists and political scientists in USA) from three universities, varying in prestige, show that scientists trained at a 'major' university are more likely to be productive than those trained in other universities. Similarly more scientists at the 'major' university have high recognition (58 percent) than the ones at the next prestige level (35 percent) or those from 'minor' universities with (17 percent) [Crane, 1965:710]. Crane holds that though productivity and recognition are positively correlated, yet the correlation is not direct. She states that "highly productive scientists at the major university were more likely to have won recognition than highly productive scientists at a lesser school .... <u>productivity did not make the scientist as visible to his colleagues in his discipline as did a position</u>

in a major university" (emphasis added). (Crane 1965: 710). Though Crane did not proceed further to identify all the possible reasons for differential level of recognition, she nevertheless highlighted the role of particularistic characteristics in the distribution of reward system in science.

Caplow and McGee (1965) in a similar vein state that the initial choice of a graduate school significantly affects a student's career. They believe that scientists trained at smaller universities with low prestige have no chance of gaining recognition of any kind. Hargens and Hagstrom (1967) based on their study of 576 physical and biological scientists have shown that while particularistic characteristics like the prestige of the graduate school attended have relevance in the early stages of a scientist's career, universalism becomes predominant later on.

However, the main problem with studies on research productivity and stratification in science by Merton and his followers is that they have concentrated on, or considered as relevant, only the highly productive and eminent scientists for their studies. Though they have acknowledged the existence of a large number of relatively less productive or totally unproductive scientists, they have only brushed aside their existence as insignificant and have made little effort to study their role and performance within the system of stratification in science. But it is this large number of peripheral scientists

who are of special interest to us. Within the stratification of international science, Indian scientists are peripheral and among the scientific community in India, university scientists occupy the lower rungs of the stratification system. The dynamics of science among them may be based on entirely a different set of norms.

In sum, we can say that studies within the Mertonian model have primarily concentrated on the processes of communication, especially collaboration and competition, on research productivity and reward system primarily to highlight the functioning of the norms propounded by Merton. In doing so, stratification in science has emerged as an inevitable problem area. But the Mertonians justify such inference on stratification and relate it to effective functioning of the norms of science. However, the Mertonians rely heavily on the research productivity or the performance of scientists to illustrate stratification. The actual process of 'doing science' which precedes scientific output has received little attention. Though the importance of informal communication patterns among scientists has been emphasized as pointed out earlier, systematic studies on this aspect have not been pursued. In our study, by focusing more on the informal academic and extra-academic linkages among scientists, we aim to arrive at a better understanding of the performance of peripheral scientists.

1.2 KUHN'S NOTION OF SCIENTIFIC COMMUNITIES

The notion of 'scientific community' for Kuhn refers to scientists subscribing to a 'paradigm'. In a broad sense, a paradigm includes "theory, craft skills, model solutions, problems, standards and the like, allegiance to which delineates and bounds a community of specialists" (Jacobs, 1987:271). Kuhn's 'normal' communities are also autonomous and homogenous entities, as knowledge claims are made and evaluated within the community of scientists who have undergone similar training and follow the standards and techniques of the same paradigm. However, in contrast to Merton who sees scientific rewards as a result of effective functioning of the norms of science, Kuhn suggests that the purpose of rewards is to promote allegiance to prevailing procedures and ideas. His major contribution to sociology of science is that he delineates the boundaries of scientific communities that enable detailed investigation of social relations within communities. Communication between scientists are taken as a good measure for identifying the members of a specialist community. Citations of research papers are considered as the most objective and quantitative measure for understanding communication networks among scientists over space and time. However, studies within this model assume that communication and influence would be higher within communities than between them.

Price (1963) quite independent of Kuhn has also realised the importance of identifying a scientific community. In his study of networks of scientific papers (1965), he has used citations to show that the pattern of bibliographic references indicates the nature of the scientific research front. Using citations as data drawn from the Science Citation Index prepared by Garfield for 1961, he has shown that about 50 percent of the references in the research papers of an area link them with a small set of recent publications. The remaining references link these randomly with the broad scientific literature. His analysis shows that literature in the basic sciences consists of tightly knit clusters of papers, which are in turn loosely linked to a large number of other clusters.

Price states that his findings reveal the existence of two different literature practices and of two different needs on the part of the scientist: (i) The research front builds on recent work and the network becomes very tight. To cope with this the scientist (particularly in physics and molecular biology) needs an 'alerting service' that keeps him informed about the work of his peers and colleagues by citation indexing (ii) The random scattering of citations corresponds to drawing upon on earlier works. This represents that part of the network, which considers every published paper as a record of knowledge generated. The traditional practice is to systematize such knowledge from time to time in the form of books which serve as useful sources of

reference over a period of time (1965: 515). However, Price concludes that such literature only remains in the background and is far from the central and strategic papers that give rise to closely knit clusters of scientists and the growth of knowledge.

Several scholars following Kuhn and Price have attempted to study the social organisation of research areas. Kadushin (1966, 68) uses the concept 'social circle'. He however concedes that 'social circle' is not a sharply definable concept. The members of this group are separated geographically and face-to-face interaction hardly occurs. Thus a scientist can be influenced by the publications of one whom he has never met and information about whose work he can receive only through conversation or correspondence with even a third party at times. He thus emphasizes Kuhn's perception wherein members of a research community are brought together by their commitment to a particular approach towards a set of problems, and not by face-to-face interaction.

Crane in her work on the Invisible Colleges (1972) has explicated the characteristics of social orgnisation of a scientific community at different stages of knowledge growth within the Kuhnian framework. Taking two research areas - rural sociology and algebra, she has identified the main scientists through citations and has gathered more details through mailed questionnaires. She argues that there are three main concepts that have to be considered when one attempts to study

communication and interaction among the scientific community whether in terms of diffusion of ideas or in terms of an attempt to understand its social organisation. They are: the 'paradigm' to which scientists subscribe to, the 'social circle' that they form naturally and the 'invisible colleges' that emerge. The last refers to the network of productive scientists linking separate groups of collaborators within a research area.

In both the research areas that she studied Crane found evidence for Price's (1963) logistic curve which says that scientific literature has an exponential growth rate doubling approximately every fifteen years. He further adds that the rate of growth of research areas within science and at times within disciplines appear to be even more rapid. Within this exponential growth rate, Crane has tried to describe the social organisation of the scientific community dividing it into four stages (Crane, 1972:172).

She says that there is little or no social organisation when a paradigm appears, but is characterised by groups of collaborators and an invisible college during the stage of normal science. There is increasing specialisation on the one hand but also increasing controversy on the other when anomalies appear in the paradigm and indicates a decline in membership when a research area reaches its final stage of being refuted. Stage two is what is crucial and Crane observed that the role of the invisible college is indispensable, since "the absence of an

effective invisible college linking groups of collaborators can inhibit the development of a field" (Crane, 1972: 54). Several other scholars have also used citations to identify scientific communities and to study the informal networks that operate amongst them and have made observations similar to those of Crane (Price and Beaver 1966, Mulkay 1969, Mullins 1972, Crane 1972, and Whitley 1972).

However, the use of quantitative or bibliographic data to study the social organisation of scientists has been under severe attack in the recent years. Citations, it is said, provide only a partial indication for inferring communication patterns among scientific communities. Collins (1974), for example, has argued that studies on formal communication as evident from published scientific literature provides a misleading view of communication within the scientific community and the social organisation of science. In his view, it is not formal but informal communication which is crucial to scientific research as it is in some sense natural and reflects the processes of interaction and negotiation.

Several others have dismissed the use of quantitative and bibliographic data to study the growth of research areas [Mulkay Gilbert and Woolgar 1975; Edge 1979]. Mulkay and others suggest that 'research networks' be regarded as the social units of scientific activity. In their view, scientists form networks gravitating from different specialities and disciplines and do

not always share the same training as Kuhn supposes. Further, these networks are much smaller than communities and are more flexible and dynamic. To quote them "networks are concentrations of interest ties without clear boundaries" (Mulkay et al., 1975:191) and "contacts with fellow scientists in non-research contexts, for example in the course of teaching or recreation, as well as with laymen... influence the direction taken by research" (Mulkay et al., 1975: 188). Edge in a similar vein denouncing such an approach to study scientific communities has made a passionate appeal calling for participant centred (scientist oriented, phenomenological) studies of science.

In sum, we can say that scholars engaged in studying communication in science have been more interested in examining how the rapid growth of science has affected the channels through which information is communicated than in invesgitating the social processes responsible for scientific growth. Thus, they have been criticised for failing to consider the content of scientific messages and also the ways by which scientific thought changes over time. However, concern with the emergence and growth of research networks has led to a phenomenal increase in the number of case studies of particular networks (Crane 1969; Mullins 1972; Law 1973). There still remain two main problems with such studies. First,some have suggested that there appears to be an increasing tendency in certain research areas to shift from pure to applied research. Such developments entail a change from

a relatively closed scientific audience to a much wider one. This may have consequences in the reward system and in the nature of social control within the system of science. There has been very little work in this direction.

Secondly, as a result of the above, eminent scientists may also be socially visible outside their research community and at the same time may also be subject to various kinds of pressures from outside. These may affect the direction given in general to research and in particular, to specific research areas which are mediated through these scientific elites. Such details have not been given due attention in studies on research networks. In addition, little systematic analysis has been done to show the extent to which internal dynamics of research networks of scientists is moulded by the institutional context in which they are embedded.

Mention should however be made of Ben-David's (1971) detailed analysis of the rise and decline of science in various world centres. He has argued convincingly that the differences in the degree of centralisation and competitiveness of the institutional system are closely linked to the growth and decline of research centres. He maintains that when the social structure produces a high level of competition, research productivity increases and the country is reorganised as a centre of world science. When competition declines, the centre of world science moves away. In other words, Ben-David has provided an

alternative to the understanding of the social organisation of science which can be called the institutional approach.

1.3 THE SOCIAL CONSTRUCTION OF SCIENTIFIC KNOWLEDGE -- KNORR AND ASSOCIATES

In response to certain developments in philosophy and sociology, new analytical perspectives in social studies of science have been emerging. They have redefined and reformulated problems of current interest and relevance in the study of science. These perspectives, especially phenomenology and symbolic interactionism advocate detailed ethnographic studies of scientific work and practice. In other words, the 'internal' practices of the scientific enterprise constitute the focus of inquiry. Thus they prefer microscopic studies of scientific practices, giving priority to questions of understanding HOW scientists go about doing science rather than trying to explain WHY they act as they do. As a result, scholars working within this perspective do not attempt sociological theorising in the traditional sense.

While some proponents (Garfinkel 1967) are indifferent to the goal of providing sociological explanation and only attempt to give systematic description of participants' interpretative practices, certain others reject the traditional form of theorising which requires formal propositions. Geertz (1973) and others call for general frameworks rather than formal propositions which would allow not only new research questions

but also accommodate different interpretations of response to these questions. Thus ethnographic studies of scientific work and ethnomethodological attempts of scientific practice try to demonstrate the diversity, incoherence and contradictions in the practice of science (Latour and Woolgar 1979; Knorr Cetina 1981; Latour 1983; Lynch et al. 1983; Woolgar 1983; Mulkay Potter & Yearly 1983).

Within this framework, studies on the scientific community have also undergone a change in focus. Knorr (1981) in her study of an American research laboratory emphasizes the fact that science cannot be understood solely or primarily at the level of ideas and beliefs. Scientific researches take place in specific organisational settings and every stage in the research process is characterised by 'selections' from things such as available equipment and materials, possible techniques etc.. These selections, she maintains, are not governed by universally fixed rules, but are very much in accordance with locally recognised standards and values since the individual scientist is only interested to 'make things work'. Therefore, each research locale, she says, appears to develop its own technical culture. The variations in research traditions, therefore, in her view, suggest a strong personal dimension to the end product of a scientific research.

She disagrees with the use of the concept 'scientific community' as envisaged by Kuhn since it does not reflect the

participants' perception of the social relations among scientists. She says that the scientist's research decisions and selections are influenced by people outside his/her research area and also outside the laboratory. Contacts are formed with scientists belonging to other disciplines, with bureaucrats, university administrators, etc. and they all significantly affect the nature of research projects. She calls these contacts 'resource relationships'. She further adds that though interests in resource relationships generally coincide, they conflict when the members of the same research team compete for promotion or for alternative employment.

This approach therefore is opposed to the traditional ones in sociology of science. It directly investigates the cognitive content of science and claims that the acknowledged scientific beliefs are the contingent outcome of social processes. Emphasis is on the diversity of the cognitive technical culture in science and on the absence of clear criteria for evaluating knowledge claims. Thus the scientist's position in the social setting and his non-technical resource relationships are brought into focus. One of the main consequences of this approach is that the largely impersonal debate that takes place in the formal context of the professional journals can be fully understood only when it is related to the more variable processes of interpretation and negotiation that occurs in the less formal contexts.

In the context of Mulkay's (1975) emphasis on research networks and Knorr's (1981) explication of role of social contacts and resource relationships, it seems necessary to point out the significance of the concepts of 'resource networks' and 'resource groups' developed by Sharma (1975). On the basis of longitudinal data on social change in an Indian Village Sharma (1975: 178-79) observes that resource networks are partial in the sense that they are an extract from the total network based on the criterion of shared interest in the mobilisation of power of formal organisations for personal ends and the nature of relationships in them is instrumental. When such relationships form a group in accordance with the interactionists conception, it may be called a resource group.

These concepts are extremely valuable in analysing the establishment of contacts and the nature of social relationships which are formed by scientists for either the promotion of science on the basis of universalistic criteria or promotion of self-interests through particularistic criteria. In the latter sense funnelling and distribution of research funds, membership of committees and even awards or rewards, can be manipulated instrumentally on the basis of 'do ut des' (I give in order that you give). Such mobilisation of power of formal organisations could result in high visibility along with 'bad science'.

Some of the observations of Knorr referred to above have been anticipated by some other earlier scholars too [Collins

1975; Wynn 1976]. Collins in his study of replication in physics states that idiosyncracy, opportunism, cognitive variability and negotiation among the participants of the research group are sufficiently manifested in his study. Hence he infers that there can be no objective criteria for judging knowledge claims as they are coloured by personal considerations such as one's faith in the experimenter's capabilities and honesty, one's views about his personality and intelligence, his social location and reputation and his access to inside information. Wynn (1976), talking about scientific consensus, observes that the acceptance and rejection of research programmes are more a part of the day-to-day process influenced by the scientists' local interests and his training.

Thus, within this new perspective the concept 'scientific community' has undergone significant change. Scientific communities are no more considered to be "homogenous, totalistic and coherent communities dominating the lives and thoughts of scientists" (Whitley, 1984:5) as Kuhn claims, but are more in line with Gusfield's critique (1975) of the concept of community in general. He says that one should avoid conceiving of societies as "groups and/or entities to which persons belong" and to envisage them instead "as points of reference brought into play in particular situations and arenas" (Gusfield, 1975:41). Scientists work in 'transepistemic arenas' which gives rise to creative research (Knorr 1982).

Such a perspective lays greater emphasis on the process of knowledge production than on the actual performance of scientists. This has provided a new turn for studying the dynamics within the scientific community. It allows us to attempt a detailed analysis of the social processes among peripheral scientists who are generally evaluated only on the basis of their performance.

SECTION II

1.4 SCIENCE IN THE PERIPHERY : STUDIES ON SCIENTIFIC COMMUNITY

In the background of the history of thinking and the shifts in perspectives on the notion of scientific community, we now take up the predominant perspective(s) in the study of science and scientists in the periphery. The problems of scientific community at the periphery may be very different from those at the centre. Scholars from the centre and other developed countries have been taking considerable interest in studying science and scientists of the developing countries.

George Basalla (1974) has provided a model to study the spread of Western science in countries of Eastern Europe, North and South America, India, Australia, China, Japan and Africa. Basalla claims that his model consisting of three overlapping phases provides a framework to assess the spread of modern

science not only in the colonies but also in the remaining countries of the world.

According to him the first phase of the transmission process is one of extension of geographical exploration where the 'non-scientific' society provides source material for the European scientists. These scientists, and they include social scientists regularly visit the •target countries, awed by their rich material: flora and fauna, religion and rituals, and customs and practices. However, all information collected is directed towards enhancing their own research in their home countries.

The second phase is called the period of colonial science or dependent science which is considered by Basalla as a transition phase. During this period, the native scientists join in large numbers the surveys of the organic and inorganic environment conducted by the European scientists. (European for Basalla refers to western European). However, for the native scientists, their educational and institutional attachments are beyond the boundaries of the land in which they carry their scientific research. The colonial scientist works under several handicaps at home, for example, the lack of well-equipped scientific institutions, lack of reciprocal intellectual stimulation etc., and hence does not really become a part of the 'invisible colleges' of the established scientific tradition. He is thus cut off from the latest news in the frontiers of science. Inspite of this, a few colonial scientists do manage to do

research that at times challenges or even surpasses research work of the European scientists. Throughout, the colonial scientists strive to create institutions and traditions that will eventually provide the basis for an independent scientific culture. Basalla says, "colonial science has passed its peak when its practitioners begin a deliberate campaign to strengthen institutions at home and end their reliance upon the external scientific culture" (Basalla, 1974: 370).

The third phase for Basalla is characterised by the establishment of an independent scientific tradition. This process involves the replacement of the group of colonial scientists who were primarily oriented towards an external scientific culture by scientists whose major ties would remain within the boundaries of their native country. For this to happen, the native scientists should not only receive their intellectual training within the country, but also have scope for intellectual stimulation from the scientific community of their country.

Besides, their profession should not only gain some respect but also bestow national honours to successful scientists. This state, Basalla observes, cannot be achieved unless the following seven conditions are met: (i) resistance to modern science by native philosophies and religious belief must be wiped out (ii) the social role of the scientist must be defined in order to ensure society's approval of his labour (iii) the relationship

between science and government must be clarified so that not only financial aid from government is available, but also neutrality to scientific research by the government is assured (iv) teaching of science within the educational system has to be popularised (v) native scientific organisations should be founded (vi) channels opened to facilitate national and international communication in science (by starting journals) and (vii) provide for a good technological base for the growth of science.

Basalla's model has been severely criticised for two main reasons. First, it includes countries from the U.S. to Australia under one category, which does not allow for explanations for differential nature of the growth of modern science due to historical reasons. For example, some were colonies, others were barren lands later occupied by migrants in search of new pastures etc. Second, the phase of dependent or colonial science is generally a very long one and requires time and tremendous pressure to decolonise and establish an independent scientific tradition. Despite these criticisms scholars have been trying to understand the growth of science in the periphery based on Basalla's model consciously or otherwise.

Studies by western scholars on science in the periphery have mainly attempted to describe and explain either the second or the third phase of the spread of western science as spelt out by Basalla. In doing so, they have adopted two lines of thinking on the problem. They have either tried to study the nature and

functioning of the different types of scientific institutions in these countries [Silcock 1964; Stephen C. Hill 1977; Eisemon 1982; Schott 1987] or have directly tried to study and evaluate intellectuals in the third World (Dedijer 1963; Moravcsik 1964; Jayasuriya 1970; Friedman 1974; Gaston 1975; Velho 1986). We will discuss only studies of the latter kind as these directly relate to our present research. Two main themes are predominant in these: (i) Communication among scientists and stratification in science in these countries and (ii) the social status and identity crisis of intellectuals in scientifically peripheral countries.

1.4.1 Communication among Scientists and Stratification in Science : Studies on Periphery

Two international surveys - Gaston (1975) and Vanderpool (1974) have attempted to show stratification in international science in line with the Mertonian model. While Gaston's survey of scientists from rich and poor countries tries to show the prevalence of 'universalism' and thus justifies stratification, Vanderpool's survey on centre and periphery in science tries to highlight 'particularism' and thus questions the system of stratification among nations. Vanderpool's sample consisted of 222 visiting foreign scientists from both developed and developing countries in the physical, biological and social sciences at several mid-western American universities. Eightytwo interviews were conducted and one hundred and forty mailed

questionnairs were received (Vanderpool, 1974: 441).

These scientists were asked to identify the countries in which research at the forefront of knowledge in their fields were being carried out and were further asked to discern the positions of their home country relative to the leading countries in their areas of scientific inquiry. The U.S. in general was acknowledged by the visitors as the leading country and the positions of four other countries (Soviet Union, France, U.K. and Japan) were seen as being interchangeable. The critical issue that Vanderpool raises in terms of difference between scientists in developing and developed nations is the impact of the ranking system of nations on the scientists who visit the U.S. In this connection he explores the positions held by scientists in the social system of work in the U.S.and the type of exchange system that exists between their home countries and the U.S.

Concerning the former, the scientists were asked to identify the nature of their current position which had been classified into main line and non-mainline positions. The main line positions are more prestigious, have higher financial rewards and entail greater involvement in the decision-making process of departmental issues than non-mainline positions. Relating the level of development of the scientists' home countries to the positions of the respondents in the social system of work in the U.S., Vanderpool finds that scientists from developing countries are more likely to hold non-mainline positions than scientists

from developed countries (Vanderpool, 1974: 437). This implies that many scientists from developing nations do not receive the same level of reward, prestige and role involvement as do the scientists from developed nations.

With respect to the other aspect - exchange networks- scientists were asked to identify communication avenues in terms of exchange of journals, transference of financial and other forms of resources, sponsorship of students, work contact with scientists, information about availability of positions in the U.S. and home countries and even gossip. What is of interest here is the direction of this exchange. Vanderpool's analysis shows that scientists from developing nations are more likely to view the network of exchanges to be non-reciprocal (flowing from their home country to the U.S. rather than from U.S. to their nations) than scientists from developed nations. Cautiously interpreting these findings, Vanderpool concludes that the linkages between the peripheral nations and the centres of scientific activity in a field are non-reciprocal, where direction of exchange can be from centre to periphery or vice-versa. Among the leading nations, exchanges are reciprocal.

Statements by two visiting scientists from two different countries given below adequately describe the difference. A West German scientist had remarked: "every week scientists in my department receive letters from Americans. Sometimes they even call each other on the phone for critical discussions on a

research problem. We often tell them of promising students who are interested in their areas and we arrange for these students to work in the United States..." (Vanderpool, 1974: 439).

In contrast a Chilean cardiologist described the non-reciprocity of exchange. The scientist feels that for the Americans, they are a 'scientific backwater' and they do not take any interest in the journals they publish or the research they are engaged in. If he or his colleagues in Chile write personal letters to those scientists at the centre about research in Chile, most often there is no acknowledgement. If he does receive a reply, it reads as "what the hell are you doing in Chile?" which is a form of invitation to him to go to the centre. Occasionally American cardiologists visit Chile for a vacation and casually visit laboratories. They often express surprise at the high quality of research work in a developing country.

In sum, Vanderpool's survey shows the existence of a differential reward system obtaining between scientists from the developed countries and those in the developing ones. He therefore suggests that future studies in sociology of science must take into account the differential status of nations in science and functions of rank for the centre and periphery. However Vanderpool also makes suggestions to counter such 'particularistic' tendencies. He proposes the formation of coalitions in the form of regional science institutions or

investment of men and resources in the social sciences or in areas in the physical and biological sciences which are not of current interest to the centres. He foresees the possibility of 'peripheries' emerging as 'centres' in this way.

Gaston (1975) attempts to account for the poor development of science in the developing countries, as follows: (i) science is not well organised (ii) financial support for science is inadequate and (iii) prospects for a scientific career are not bright. Gaston believes in studying the scientific community of these countries to investigate this problem. His survey therefore addresses itself to two main questions: (1) What are the actual career patterns of scientists in poor countries? (2) How are these patterns different from those of the scientists in rich countries?

His analysis is based on the bio-data of visiting scientists aken from the Directory of the International Centre for Theoretical Physics (Trieste) of 1970 which provides details about the scientists' educational background, research interests and research accomplishments. It consisted in all, the summarised curriculum vitae of 446 physicists from 39 developing countries (Gaston, 1975: 325).

Tracing their academic career, Gaston shows that these scientists to a large extent are highly qualified and their last degrees are generally from one of the three countries - India (28%), U.K. (20%) and U.S.A. (21%). Concerning formal and

informal communication patterns of these scientists, he shows that a considerable number held positions of responsibility outside their country and have attended conferences abroad. Regarding positions held by scientists from poor countries, he shows that 28% have held one position, 19% two, 10% three and 8% four or more positions outside their country. With limited information on conference attendance (available only for 129 scientists), he shows that 55% had attended two, 16% three or four and 9% five or more conferences of which 93% have travelled to attend a foreign conference. He further points out that only 10% of his sample scientists had no publication. Taking citations as the indicator for recognition of these scientists, his analysis shows that more than 50% of his sample scientists from poor countries have no citations of their papers. For the rest it ranged from one to a dozen citations. Comparing rates of productivity and citation, he says that:

(a) Scientists from Africa and Middle-East produce research at a slower rate than scientists from India, South America and Mexico.

(b) Scientists from the Middle-East, Greece, Far-East and India receive more citations than scientists from other countries.

Comparing some data of scientists from developing countries with those of scientists from rich countries, Gaston applauds the scientists of the third world for being able to compete with

scientists from rich countries inspite of working under difficult circumstances. Drawing support for his inference from other studies such as Price (1963), Halsey and Trow (1971) and Gaston (1973), he questions the notion that scientists in the developing countries suffer. Though he concedes that the development of science in poor countries is similar to that of the advanced countries in the 1800's, he adds that scientists in poor countries now have a distinct advantage over scientists of the developed countries who worked under similar conditions in the 1800's. For they are not embarking on some unchartered institutional activity. They know that scientific research can produce results and they are taking it up as a challenge.

In the light of these findings Gaston suggests that further studies of scientific communities in the poor countries could concentrate on the following

(i) cognitive development

(ii) institutional development and

(iii) the relation between the two.

He further adds that in cross country comparisons, structural and demographic factors of science have to be given due importance. Gaston is of the view that when one sees a country economically more developed than another, one should not jump to the conclusion that the former is scientifically more developed than the latter. The number of active scientists in

both kinds of countries has to be taken into consideration to understand the scientific pulse of the country.

Taking cue from Gaston, Velho (1986) in his study of Brazilian agricultural scientists, tries to explore the extent to which citation counts may be taken as a valid indicator of the quality and influence or impact of published scientific knowledge in the general context of a scientifically peripheral country. His study is based on both quantitative data, referring to citations appearing in a sizeable sample of articles published by scientists of four Brazilian universities located in different regions of the country and qualitative data, in the form of 95 interviews of scientists located in these universities (Velho, 1986: 74-76). His findings show that citation patterns are significantly influenced by factors 'external' to the scientific realm and thus, reflect neither the quality, influence or the impact of research work that has been referred to. Velho's analysis shows that 24% of all citations by these scientists were to their own work and that of their group, 16% to scientists from other institutions within the country and 4% to scientists in other peripheral countries (including Latin America).

Velho has identified a number of factors that make Brazilian scientists use selective literature.

(1) Competition among Brazilian agricultural research centres both for financial resources and 'priority of discovery'. The

scientists in these centres therefore do not refer to the work of their colleagues.

(2) Accessibility to scientific literature affecting exposure. Some scientists claimed that it was easier to scan foreign journals that deal with specific research areas in contrast to domestic journals that are largely of a general nature. The educational background showed 60% of them were trained abroad and therefore generally referred to the literature produced abroad, especially of scientists known to them. Many even subscribed to such journals.

(3) Heavy reliance on 'Abstracts' to keep track of the overload of scientific information produced. As Brazilian journals are poorly indexed, their awareness of research done in Brazil is poor. Besides, some Brazilian scientists opined that citing advanced country publications conferred more prestige on their work.

Thus, Velho shows that as the international flow of scientific information is imperfect, citations cannot provide a reliable measure of judging the quality of research output in the periphery. He says that data are available on the poor subscription pattern of journals from the periphery at the centre. Language is a major barrier to subscription of journals of other countries. Even if scientists from the periphery do publish their research work in journals from the centre, the data are regarded with distrust. One of Velho's interviewees had

illustrated this point by citing his personal experience during his doctoral programme in the U.S. The Brazilian scientist was given a handout while attending a genetics course. The handout was on breeding maize and contained a statement as follows : "Webel and Lonquist in the U.S., had obtained a 9.44% gain per year with their new maize hybrid and Parteniani, in Brazil, got a gain of 13.6% with his". It went on to say that "Parteniani's results were remarkable, if true" (Velho, 1986: 79). In his conclusion Velho suggests that considerable work on the referencing behaviour of the scientists in peripheral countries should be undertaken before one can interpret citations meaningfully. Such an exercise may be more useful to develop additional means of measuring networks of influence between and within scientifically peripheral countries. Finally, he pleads for citation studies to complement their quantitative data with qualitative information that would throw more light on the environmental determinants of the research activity of the community studied.

1.4.2 Social Status and Identity Crisis of Intellectuals in the Periphery

Some scholars while trying to describe and explain science in the developing countries in terms of Basalla's model have highlighted the poor social status of intellectuals or the identity crisis they undergo in trying to establish an

independent scientific tradition. (Dedijer 1963; Moravcsik 1964; Jayasurya 1970; Friedman 1974).

Dedijer drawing support from statistical data of his earlier surveys (1960, 1962) and some United Nations reports (1963, 1965) has described the nature of scientific community in developing countries. Scientists in developing countries are few and dispersed over long distances. As a result they suffer from isolation and do not enjoy the benefits of the stimulation of the presence of scientists working in closely related fields. They therefore face the danger of losing the few contacts they have with colleagues in the international scientific community. They feel peripheral with respect to the frontiers of science and harbour a sense of inferiority as their scientific journals and their scientific societies are seldom acknowledged by the scientists of the leading centres. Further, Dedijer states that these scientists have little contact even with colleagues in the neighbouring underdeveloped countries. As a consequence, the scientific community in these countries are 'frail and anaemic' and their links with the political leaders of their respective countries are rather weak. Thus, when scientists are not prominent, or well recognised even within their professional group, the social status with respect to their occupation is also very low. In other words recognition from the society is also poor.

In Dedijer's view "underdeveloped countries have scientists but no scientific community, if we define the latter in the light of what exists in the developed countries, as an organised group with a developed system of beliefs, with a developed system of institutions for internal communication, as well as a system of communication for dealing with other social groups, and which is bound by certain traditional norms of behaviour for furthering their individual and collective work, in science" (Dedijer, 1963: 79). The main reasons for this status, Dedijer identifies as economic dependency and the lack of a culture of science in these countries. He therefore foresees a bleak future for science in them unless the political leaders direct some attention towards the re-structuring of scientific institutions and strengthening of the 'scientific community'.

Assessing the role of technical assistance and the nature of fundamental research in the underdeveloped countries, Moravcsik (1964) identifies the indifferent attitude of scientists in these countries as being primarily responsible for the nature of poor quality of research. The few scientists trained in the developed countries, on return occupy key positions in research institutions and due to lack of competition from scientists at home generally tend to stagnate. Instead of transmitting the latest knowledge to students in their countries, they end up teaching science of the 1920's and 1930's which they had studied. As a result, they also lose their contacts with the active

scientists of the developed world. Moravcsik does not foresee chances of the developing countries to build strong scientific traditions of their own, unless a change in the attitude of scientists takes place. He however rejects the view that underdeveloped countries should concentrate more on applied research or work on problems generated by the scientists at the centre.

In contrast to the observations of the above scholars, Friedman (1974) tries to give a picture of the Brazilian intellectuals and their struggle to create an independent scientific tradition within their country. The intellectuals mainly trained abroad, look outside their country for inspiration in order to create the foundations for a new moral order and raise their country from disintegration. They see in science and technology the means by which progress can be achieved and therefore try to propogate the concept of 'economic development'. However, this concept is a dynamic one and carries with it a tradition of definition of values, ideas and aims. The Brazilian intellectual, caught in the current of western values and ideologies is unable to transfer them directly to specific instances in his country. At the same time he is compelled to create a national self-image for which he looks back into his tradition in search for some distinctive values that are specific to his culture. In opposition is his passion for professional achievement which often tempts him to leave the country to join

the environment where his professional talent would receive recognition.

Jayasuriya (1970) makes similar observations in his survey of Ceylonese (Sri Lanka) scientists. His primary focus in the survey is on scientists and technologists, characterising them as a distinct professional group in the Ceylonese society. He relates their status to the organisation and development of science and technology in Ceylon.

His analysis shows that most of them come from western-educated middle class (33 out of 54), which he says is no surprise as education has been accessible only to the middle class who view it as a means of upward mobility. Another important observation is that the scientists view their professional role as still ill-defined. This uncertainty of their role, Jayasuriya points out, is due to their displacement, as they have been largely trained in the western 'know-how' whereas the emerging society draws its political ideologies and social values from the traditional Sinhala and Tamil populations. Committed to the ethos of modern science, they are caught between the traditional and the western. They are aware that the success of modern science is closely linked to a particular economic system - an industrial rather than an agricultural one. Jayasuriya here highlights the peculiar problem of the developing societies. Almost total rejection of traditional agricultural economy in order to practice modern science and transform

society is a difficult choice for these countries. He has shown how only a few years back (late 1960's) the scientific policy of Ceylon shifted its focus from the plantation sector (which is the mainstay of the country's economy) to the industrial sector. His sample survey reflects such a trend. Only 40% of the scientists were chemists, the remaining 60% were either Botanists or other biological scientists, while physicists were conspicuous by their absence. The scientists interviewed were therefore of the opinion that only a 'directed change' introduced with government-patronage towards science and technology can bring a change in the value and attitudes of the people.

We have shown that studies on the scientific community at the centre, have mainly focused on the ethos and norms of science, the social processes such as communication, cooperation and conflict involved in the 'doing of science', and the social organisation of the scientific community. However, some of these issues are very much relevant to study science in the periphery too.

Studies on science in the periphery have tried to test Basalla's model of the three phases of development in the growth of modern science in the developing countries. They have highlighted the conflict between the values and ideas of the native tradition and the alien tradition of modern science, identity crises of intellectuals in developing countries,and the

ineffective functioning of scientific institutions etc. Following the western models of sociology of science, they have repeatedly attempted to demonstrate the poor quality of science, lack of a scientific community and the ineffective functioning of the norms of science. However, it should be noted that all these endeavours have always tried to study scientists, scientific institutions and science in the periphery only in the context of the centre and their relations with the centre. Thus studies on scientific community in the periphery have attempted to find linkages between scientists of the developed and developing countries (or their absence), and demonstrate the extent of integration or fragmentation.

However, their studies only provide negative indicators towards integration and promote a system of international stratification in science. Peripheral countries generally occupy the lower rungs of this stratification. They thus condemn science in the periphery as being of low quality and little significance.

Obsessed with such beliefs studies on science in the periphery, have not investigated the status and problems of science and scientific community specific to peripheral countries. They have thus failed to provide meaningful explanations for the poor impact of science produced in the periphery.

It is true that some studies have attempted to provide descriptive details of particularistic and country specific features related to the genesis and growth of modern science, but they have not been successful in providing any alternative model to study science in the periphery. However, in the light of the above discussion, we will now examine in some detail studies on scientific community in India.

SECTION III

1.5 STUDIES ON SCIENTIFIC COMMUNITY IN INDIA

One comes across a bulk of literature on science and scientists in India, but systematic and analytical studies falling within the scope of sociology of science are few and have been sporadic. Works in which scientists have been studied as members of an organisation largely fall within the scope of sociology of organisations and those in which they have been studied as constituent members of a profession could belong to sociology of profession. Apart from these, there exists a body of literature on the scientific community in India which studies scientists in relation to the nature of scientific research pursued and produced in the country. It is this body of literature that can be legitimately claimed to belong to the sub-area of sociology of science.

The earliest studies on the scientific community in India within sociology of science were surveys of scientists from universities and research institutes (Ahmad and Gupta 1967; Sinha 1970). These were conducted to test the prevalent notion in the late sixties that the poor scientific output in India was due to the religious, 'other worldly' attitudes of its scientists. While rejecting such a thesis, these surveys identified the lack of a conducive organisational environment and scarcity of funds as the major factors responsible for the poor quality of scientific research in India.

The role of the organisational environment in the success of scientists, research groups and laboratories received attention of scholars (Singh 1970; Visart et al. 1984; Chakravarthy et al. 1986; Aurora 1989). Singh (1970) in his study of the Trombay establishment (later named Bhabha Atomic Research Centre - BARC), attributes the success of the establishment to Bhabha's style of functioning. He describes in some detail how Bhabha created an organisation for Indian scientists that gave them full opportunity to develop themselves, take responsibilities, make mistakes and learn from them through a system of collegiateship and democratic functioning. Bhabha involved the scientists in the organisation's decision-making process and gave them due credit to in the organisation's accomplishments. Bhabha believed in a certain mobility of personnel and took a number of steps to keep the organisation young. Above all, his personal rapport

with the scientists helped in the efficient functioning of the establishment.

The organisational influence on the performance of scientists has been studied even at the level of cross country comparisons. The International Comparative Study of Performance of Research Units (ICSOPRU) conducted by UNESCO in 1978 is of this kind. Data were collected from six countries of Europe and Asia. The National Institute of Science Technology and Development Studies (NISTADS) was the Indian participant. A sample of 200 research groups working in different scientific fields and in various types of institutions such as academic, government and industrial research in India were surveyed.

One of the main findings of this survey is that heads of research units play a determining role as far as the quality and productivity of their units' R & D work are concerned. However, their results do not indicate a correlation between the type of institution and the degree of autonomy enjoyed by the head -- autonomy in decision-making, autonomy in contact building and autonomy in scientific matters. This finding goes against the widespread opinion in the scientific community that heads of research units in university settings are much less subject to harassment by the university bureaucracy than their counterparts working in other kinds of institutional settings (Visart et al., 1984:3). It is the socio-cultural milieu of the different

countries that is identified as affecting the productivity and achievements of research units.

In contrast, Aurora (1989) attempts to relate the institutional structure of scientific institutions and the performance of the scientists. Tracing the development of modern science in India, he points out that a number of scientific institutions has been set up after Independence outside the framework of universities. These institutions do enjoy a high degree of autonomy in their research goals but their internal structure remains highly centralised. Instead of developing a collegiate culture, these institutions have become highly bureaucratised. As a result, scientists working in these institutions are unable to meet the organisational requirements for a rigorous practice of 'Big Science'. Neither are they able to satisfy the society that expects concrete results in the form of applied research.

Considerable interest therefore was generated to study personalities and research institutions they had created (Anderson 1976). His work on Bhabha and Saha offers an insightful comparison between the two important scientific institutions: Tata Institute of Fundamental Research (TIFR) and Saha Institute of Nuclear Physics (SINP) - built by two prominent scientists under entirely different conditions.

Saha used Bengal and its institutions to build his research institute. He had to rely on the Bengali politicians to deal

with various obstacles in organising research. Bhabha, a Parsi from a renowned family, came into contact with important political personalities in Bombay and Delhi. Bhabha started his institute in 1945 with a small amount of money but large funds were guaranteed. Bhabha combined his energy, scientific reputation and his family connections to obtain large sums of money from private and government sources. The institute soon became self-sufficient at a considerable cost (Anderson, 1976:2). The institute that Saha founded in 1950 remained small and inspite of his wide contacts within the political system during the 1930's and early 1940's, he was unable to secure a steady source of funds for his institute. It became almost wholly dependent on the Department of Atomic Energy (DAE) and on Bhabha after Saha's death in 1956.

Before we turn to the studies on fragmentation of the Indian scientific community which directly concern us, we wish to mention an important work of Shiv Viswanathan (1985). His is a study of the process of transfer of research results from laboratory to industry. This study of a research unit of the National Physical Laboratory (NPL), an institution that was to contribute significantly to the technological revolution in the country, is an investigation to understand how the scientists, mostly recruited from universities, learn to bridge the gap between science and technology. The author attributes the less than satisfactory performance of these laboratories to the

absence of any attempt in India "to create a structure combining excellence and relevance, maintaining accountability and yet allowing science the autonomy its creativity demands" (Viswanathan, 1985: 261). In contrast, science in the western metropolis is properly integrated with the requirements of technology. In fact, the new culture of 'scientised technology', is a response to tackle problems of technology in defence, electronics, space etc.

With such diverse material produced on scientific institutions and scientific community, the emphasis shifted to the nature of the actual functioning of the scientific community in order to understand their performance (Shiva and Bandhopadyaya 1980; Arunachalam 1981; Jairath 1984; Guay 1986; Ahmed 1989). Jairath relates the poor performance of the Indian scientists to the unsatisfactory working conditions and the nature of development of modern science in the country. He illustrates how science during the colonial period grew at a slow pace and how the contribution of the state to its development was minimal. After Independence, science grew very rapidly under the patronage of the state. This quantitative growth was at the cost of quality. The universities which had the potential for the development of an autonomous scientific community in the country were affected in two ways. One, the setting up of heavily funded advanced research institutes resulted in large funds being diverted to these institutes at the cost of universities. Two,

top ranking scientists left the universities when they were offered better salaries and perquisites. Jairath identifies this differentiation between the elite institutions practising 'Big Science' and other scientific institutions as a major problem.

Surveys of scientists have been conducted to explain the variations in the quality of scientific research within the country. Communication patterns and the eventual integration or fragmentation has been the main focus of such surveys. Shiva and Bandhopadhaya's Survey (1980) of 73 scientists from different elite scientific institutions within the country shows that stratification exists even among the elite scientists. Research for these scientists, <u>is directed towards receiving recognition from the advanced countries that are the 'centres' of international science</u>. This, they say, is manifest in the areas and problems they choose for research. Consequently , their interaction with fellow scientists working in different institutions within the country is minimal. Besides, there exists no common set of values and commitments among the members of the scientific community which are essential for the development of modern science. They, therefore, attribute the marginal and stagnant character of Indian science to the high degree of fragmentation among scientists.

Citation analysis has also been used to unravel the functioning of the scientific community. Guay (1986) uses citations of Indian scientists as reported in the Chemical

Abstracts to study the emergence of basic research in organic chemistry in the country. He infers that from the initial stages, chemists in India have been conducting research in isolation from each other in three groups -- British scientists, Indians trained under British and the second generation Indian scientists trained under Indian scientists. He highlights the disparities that have existed amongst these three groups in terms of research fields and publication outlets and it is these that have lead to fragmentation among the scientists.

Arunachalam (1981) uses citations to illustrate the peripheral nature of Indian science. Scientists publishing in Indian journals, he notes, cite other Indian scientists working in India alone and they are not cited by scientists abroad. In other words, science published in Indian journals has very little connection with the mainstream of international science. Arunachalam, therefore, wonders as to whether Indian science is an island in itself.

Ahmed (1989) has made a detailed survey of the processes of interactions crucial for science research. He has focused mainly on the supervisor-scholar consultations, scholars' perception of their environment and the academic values of both. Studying scientists from two different types of scientific institutions (universities and IITs) he observes that supervisor - scholar interaction is minimal. This is due to the fact that nearly 40% of the supervisors have more than 4 scholars per head which

limits the scope of meaningful interaction as supervisors have other obligations such as teaching, administration, etc. besides guiding research. As a result, supervisors do not actually 'participate' in research for they are unable to devote enough time to monitor its progress or check the results carefully. Ahmed also shows that the supervisors and scholars especially in universities, are hardly aware of research facilities available in the country, and are equally unaware, of the work in the front-line areas in their respective fields. These along with the absence of linkages among scientists, in Ahmed's view, give rise to poor quality of scientific research in the country.

Some scholars have tried to explain the malaise within the scientific community as a result of the larger socio-political milieu of the country (Shils 1969; Eisemon 1982). Analysing the science establishments of the country in the framework of C.P. Snow's types of politics, namely 'committee politics', 'hierarchical politics' and 'court politics', Morehouse shows the extent to which priorities for scientific work, funding, conditions of work, utilisation of research results, appointment of personnel etc., are determined by the politicians and bureaucrats of the country. This interference of the political system on the functioning of science and the scientific community, in his view, has affected the autonomy of the science establishments, which is essential for scientific research.

Arguing in a similar vein, the Rudolphs (1972) through a detailed study of education and politics in a few universities of the country, demonstrate the extent of local interference on the functioning of universities. In their study of M.S. University of Baroda, they have illustrated the extent of influence of local patrons who generally outnumber the academicians in several important committees of the university. They sometimes interfere in matters which should be left to the academicians. For instance, they even persuaded the university to offer a course on Community Development in place of Research Methodology. Such interference ultimately results in the perpetuation of 'parochialism' as against the desired 'cosmopolitanism', which in the view of the Rudolphs is essential for the development of science.

Similarly, Eisemon (1982) in his comparative study of two universities - one in India and the other in Kenya - observes that the taking over of the universities by the state in India has resulted in interference with rather than control of educational expansion. Expansion according to him led to indigenisation and a lack of integration across the country.

All these studies point out in one way or the other the absence of an integrtated scientific community in India which explains the poor quality of science produced in the country. Attempts have been made to study the actual functioning of the

scientific community, but they are rather limited in their scope. They have mainly restricted themselves to study the elite and successful scientists and have highlighted the fragmentation that exists even among them. The relatively poor performance of the majority of scientists especially working in universities are attributed to the local socio-political influences and hence they are rarely targets of detailed analysis. Moreover, these studies have not given due consideration to the pockets of excellence – individual scientists or groups of them who not only survive in the same milieu but have also found places for themselves in international science.

Stokes (1982), for example shows how two research groups, one in India (Bangalore) and the other in New Zealand (Christ Church) made independent and simultaneous contributions to Molecular Bio-physics by suggesting an alternative to the W.C. model of the three dimensional molecular structure of DNA. Stokes refers to this as an instance of deviance in the Kuhnian model. Kuhn allows for anomalies to occur within the paradigm (to be resolved later), but probably did not anticipate a radical innovation from outside the paradigm to cause a crisis of confidence within the paradigm. Though the contribution of these two groups of scientists was subject to a lot of criticism, it could not be ignored (Stokes, 1982:209). As Francis Crick himself acknowledged, it helped them to sharpen their arguments in favour of the Double-Helix. This analysis of Stokes might

provide some solace that though science in India is at the periphery, it has some advantages, for it allows unrestricted questioning of knowledge for the alert scientist.

In this context, mention must be made of those isolated attempts that have been made by scholars which suggest alternate ways of doing science in India (Uberoi 1978; Nandy 1979, 1980). These works call for a detailed study of beliefs and practices of indigenous knowledge systems. As our endeavour is not an attempt to investigate the possibility or relevance of doing 'alternative science', we will not go into details of this line of thinking.

1.6 PROPOSED RESEARCH

While studies on the scientific community have emphasized the fragmentation among scientists leading to their poor performance little attempt has been made to study the actual nature of fragmentation. Besides, scientists have been studied without reference to their institutional affiliations. Fragmentation among scientists at the institutional level has hardly received any scholarly attention. Further, studies on communication among scientists have largely depended on formal established modes of communication, such as journal publications, citations etc., while informal modes such as correspondence, informal discussions, visits to institutions etc. have hardly been emphasized. Above all, one can remark that studies on the scientific community are mainly evaluative in nature. Performance in science is the main indicator, on the basis of

which future trends in the growth of science are predicted. Performance has hardly been seen in relation to the 'process of doing science'.

Our attempt here is to bridge at least some of these gaps. We wish to understand the nature of fragmentation among scientists at the institutional level. Our target institutions, are the universities, which form the bulk of scientific institutions, but have been much neglected in studies on the scientific community. In our attempt to understand communication patterns among scientists, detailed information on scientists' informal interaction patterns with fellow scientists and others in the society will be given due emphasis. In studying scientists from a specific kind of institution across the country, we aim to not only understand problems at the micro level, but also identify issues at the macro level.

The specific objectives of the study are

(i) To study the formal and informal research interactions of scientists,

(ii) To examine the role of academic and extra-academic linkages of scientists with the rest of the scientific community in the 'doing of science' and

(iii) To explicate how these linkages determine the visibility of scientists.

In brief, the study attempts to understand WHAT is communicated, relates it to HOW scientists communicate and

finally WHY they function in the ways they do.

Since the study is concerned with the fragmentation at the institutional level, some background information on the institutional development of modern science in India seems to be in order. We provide some details on this aspect in the following chapter.

1.7 PLAN OF CHAPTERS

The following chapter i.e. (II) provides a descriptive account of the institutional development of modern science in India. The discussion covers the development in both the periods: Pre- and post-Independence India. Chapter III is divided into two sections. The first section identifies the field and elaborates on the research plan of the study. The second section gives some historical details of the selected universities and departments for the present study.

Data analysis is then taken up in the next four chapters - from IV to VII. Chapter IV focuses on the organisational features of the seven departments. The first section discusses aspects such as teaching duties, infrastructural facilities and the system of headship in the seven departments. The second section attempts to understand some of the norms, values and beliefs developed and practised towards teaching and research by looking at the educational background and career profile of the scientists in the seven departments.

Chapter V has for its theme the research interests and productivity patterns of scientists in the selected departments. Beginning with their initiation into research activity as evident from their doctoral background, the chapter discusses in detail the nature of research interests of scientists, shifts in interests if any and their reasons for doing so. The second section deals with scientists' productivity patterns of research publications. Analysis is carried out with respect to publication outlets in terms of specific journals, countries from which they are published and active years of high productivity.

The main concern of Chapter VI is the dynamics of internal and external research interaction of our scientists. Starting with an analysis of established formal communication patterns, as inferred from an analysis of authorship patterns of publications, the emphasis shifts to informal communication processes of scientists. Detailed analysis is attempted on the nature of internal interaction (with colleagues within the department) and the span of external contacts of respondents. The third section of this chapter examines other academic (external) interaction of scientists. Their conference participation, membership of associations and non-research publications are discussed.

The last analytical chapter i.e. VII tries to understand the extent of 'visibility' and 'power' experienced by the scientists of our study. Following an analysis of the rewards, awards obtained by our scientists, which are indicators of recognition,

the discussion gradually moves to the involvement of our scientists in 'organising science' nationally and internationally. Aspects such as the nature of conferences convened, official positions held in scientific societies/academic bodies, membership in committees and the placement of their research students constitute the focus of the discussion. These provide some insights into the domains of power of scientists from the seven departments, and some useful information on the extent of their integration with the rest of the scientific community in the country.

The concluding chapter, i.e., VIII presents a model of two polar opposites. These are two 'ideal types' -- one representing a highly successful department nationally in terms of 'big science' and hence explicating those conditions characterising 'good science', and the other all the features that characterise 'bad science'. It is worth noting that both these 'polar opposites' are isolated from the larger scientific community. The implications of these two polar opposities for the 'organising of science' in the country are also discussed.

CHAPTER II

MODERN SCIENCE IN INDIA: INSTITUTIONAL DEVELOPMENT

The main concern of this chapter is to provide a background to the development of modern science in India. Scientific research, educational policy and the expansion of institutions during the colonial period are discussed in the first section of the chapter. Following this, is a review on the role of Nehru in steering the science policy of independent India and the organisation of scientific research and education since independence. The chapter concludes outlining some of the issues and problems generated within this institutional development of modern science in India.

Modern science and technology were introduced in India by the British, which replaced the traditional system of Sanskritic and Arabo-Persian learning prevailing at that time. Besides, it was also introduced in English language, which was not the language of the country. The government established various services to cover the fields of medicine, engineering etc., as a part of the military organisation, in order to either alleviate the sufferings of the masses, or to meet the requirements of the imperial power. The main purpose was to ensure the military, administrative and economic control over the country. A conscious policy was adopted to keep the native Indians away from

responsible positions. However, despite these factors, a viable infrastructure of science and technology came into existence. We discuss this development in some detail in the following sections.

2.1 SCIENTIFIC RESEARCH IN PRE-INDEPENDENCE INDIA

The main scientific activities in the government sector were largely carried out by the Medical and Engineering Corps. of the Army and Civil officers interested in science, as a spare time activity. These men trained in European institutions and laboratories spent the most active years of their lives in India and hence left behind a rich record of their work in various branches of science. Apart from their original contributions, they had also left behind a good number of scientific instruments, chemicals and other research tools that they had used. They had also initiated a number of important scientific institutions in the country. In brief, a tradition of dedicated scientific research had been created which was continued by Indian scientists later.

There was also a simultaneous effort to promote surveys of flora and fauna in India. With the establishment of the Botanical Gardens in 1788, systematic botanical studies became possible. Dr. William Roxbery was the first to start research on Indian plants in Botanical Gardens. The Botanical Survey of India was established in 1890 with Sir George King as Director (Rahman, 1984: 23). The Asiatic Society was founded in 1784, by

Sir William Jones, judge of the Supreme Court, who was also its president. Through the efforts of this society, the Indian Museum of Calcutta was founded in 1866. But zoological research in India dates back to the appointment of Edward Blyth as the curator of the museum of the Asiatic Society in 1841 even prior to the founding of the Indian Museum of Calcutta (Rahman, 1984: 23).

Similarly, geologists were employed for survey work since 1818. A series of discoveries of Siwalik fossils were made, and research on these were conducted by H. Falconer and P.T. Cautlay who were jointly awarded the Wollasten Medal of Geological Society of London in 1837 (Rahman, 1984: 23). An agricultural society was established in 1821. But research in agricultural sciences began with the establishment of the Agricultural Research Station and Experimental Farm (later known as the Imperial Institute of Agricultural Research at Pusa, Bihar) with the help of a donation made by an American philanthropist Mr. Henry Phipps of Chicago, who provided funds for research and education in agriculture. Separate departments of Agriculture were set up in the various provinces. Agricultural colleges were established in Pune, Kanpur, Nagpur, Coimbatore etc. In 1921, agriculture which was till then a central subject, was transferred to the provinces. The provinces were to take care of policy and administration and co-ordination of research and education in agriculture. A Royal Commission on agriculture was

appointed in 1926 to examine and report on conditions of agriculture and rural economy. Based on its recommendations the Imperial Council of Agricultural Research was established in 1929 with the object of promoting, guiding and co-ordinating agricultural research and education in India. It was also to serve as a link between agricultural institutions in India and abroad.

The high incidence of diseases unknown to the west, cost of their treatment and their impact on army and administration necessitated research relating to diseases like cholera, plague, malaria, beri-beri etc.. In 1892, the Bacteriological Laboratory was set up in Agra under the headship of Mr. P.H. Hankin. The spread of plague in Bombay in 1896 led to the deputation of Mr. W.M. Haffkine to work on this problem. In 1899, Haffkine developed a plague vaccine and established a small laboratory in Bombay called the Plague Research Laboratory. It was renamed Haffkine Institute in 1926. The Pasteur Institute was established in Kasauli in 1900 and another at Conoor in 1907. The king Institute was set up in Madras in 1903 for general bacteriological research. The setting up of a school of Tropical Medicine was proposed in 1910 by Sir Leonard Rogers. Thus a number of institutes with facilities for medical research were established and a cadre of scientific workers created.

It may be of some interest to note at this juncture that while only those areas of science and technology that served

British interests were encouraged, industrial research and needs of industry were not given any attention by the British. The latter was primarily due to the fact that the colonial policy was to keep India as a supplier of raw materials to British industries and a market for British manufactured goods. Much later, due to the pressure of the national movement and requirements of the world wars, an Industrial Intelligence and Research Bureau was established in 1935 that laid the foundation for industrial research. In 1942, an Industrial Research Fund was created by the government for the purpose of fostering industrial development in the country and the Council of Scientific and Industrial Research was constituted as an autonomous body. Proposals for the setting up of a National Physical Laboratory and a National Chemical Laboratory were made. Plans for laboratories in other areas such as food technology, leather technology, chemicals etc. were formulated but these took concrete shape only after independence (Rahman, 1984: 24).

Two important features can be discerned in the development of modern science and technology during the colonial period. Firstly, though a policy of promoting science and technology was guided by political considerations, yet a number of dedicated British scientists made notable contributions. Research in agriculture, medicine, botany and zoology were significant. Besides, these scientists also established a number of scientific and professional societies and associations. Secondly, the

wly created scientific and technological infrastructure arted interacting with local situations and opportunities. The /o world wars gave a major thrust in creating organisations for search and establishment of industries. The linkages between ne scientific community and political leadership of the freedom ovement pressurised the government to improve facilities for cience and technology. Thus when India became independent, a airly established scientific and technological base was nherited from where it could take off in contrast to many other eveloping societies.

.2 EDUCATIONAL POLICY DURING COLONIAL PERIOD

During the early years of the nineteenth century, the dministrative requirements of the British rule had motivated everal Indians to take up the study of English. Simultaneously he British also realised that if knowledge, based on modern science had to be disseminated in India, it had to be through English. This resulted in the establishment of a number of colleges in various provinces which adopted English as the medium of instruction and western learning as the focus of academic activity.

It was much later in 1857 that the first three modern universities were established at Calcutta, Madras and Bombay. The university of London was adopted as the model for these three presidency universities. They were generally of the affiliating

type and the existing colleges of the respective regions were affiliated to these three universities.

In the year 1902, Universities' Commission was appointed by Lord Curzon. As a result of its recommendations, the universities were asked to undertake some teaching on their own and carry out research as well. Consequently, Sir Asutosh Mukherjee, an influential figure in the University of Calcutta at that time, led the movement for the establishment of post-graduate departments and research in Calcutta University in the early 1920's. He managed to bring together a group of talented youngsters and created the model of a teaching university in India for the first time.

However, the first university to break new ground following the recommendations of the Commission was Banaras Hindu University (BHU) which was established in 1916. It deviated from the earlier affiliating models and was set up as a teaching, unitary and residential university. In the same year, the university of Mysore was established. It was the first university to be set up in a princely state by the Maharaja of Mysore. The Nizam of Hyderabad, following the example of Mysore founded the Osmania University in 1918. Osmania University undertook the experiment of teaching through the medium of Urdu. This went on for three decades when it was finally abandoned after India became independent and Hyderabad was merged with the Indian union.

Several other universities were founded since then at the initiative of educationists, members of royal families and wealthy philanthropists. For example, the Annamalai University was founded by Raja Sir Annamalai Chettiyar (1929), University of Saugar by Sir Hari Singh Gour, an able lawyer and writer (1946) and the M.S. University at Baroda by the maharaja of Baroda (1949). (Singh, 1985: 1420-1421). The Indian Institute of Science Bangalore was founded by Jamsetji Tata in 1909. Unlike the universities of the times, it was to be an institution of higher learning and research.

Several universities were established during the early years of the twentieth century, but only four universities, namely Patna (1917), Nagpur (1923), Andhra (1926) and Agra (1927) were of the affiliating kind. The others, including those mentioned above were all teaching and residential universities.

Since 1929, the slump in the social and economic development of the country affected the establishment of universities. Only one university, that of Travancore, was established in 1937. This was the third university in a princely state after Mysore and Osmania. At the time of independence therefore, there were only 20 modern universities.

2.3 INDIAN SCIENTISTS DURING THE COLONIAL PERIOD

The British scientists working in India did create a tradition in modern science and made significant contributions, but this aspect should not undermine the role and the

contribution of Indian scientists. The first Indian to take an initiative to build a scientific institution was Mahendralal Sircar (1833-1904). He had graduated in 1860 from the Medical College at Calcutta. However, after a few years, i.e. in 1867, he was dismissed from the Bengal branch of the British Medical Association for supporting the cause of homeopathy. He then started a journal of medicine to express his views and in the issue of August 1869, proposed the need for the establishment of a national institution ' for the cultivation of the physical sciences by the natives of India' (Biswas, 1969: 52). He received tremendous support from wealthy citizens and princes in response to his appeal and by 1876 he had collected sufficient funds to launch the Indian Association for the Cultivation of Science in Calcutta. It was initially located in a house donated by the government of Bengal. The first research laboratory was instituted in 1890 where several Indian scholars including Sir C.V. Raman, the only Indian (by nationality) who won a Nobel Prize in science later, carried out their research (Jairath, 1984: 116).

Calcutta was the centre of science teaching at the turn of the century, J.C. Bose, trained in Cambridge and London and P.C. Ray educated at Edinburgh were teaching physics and Chemistry respectively in Presidency College, Calcutta. The leadership of Sir Asutosh Mukherjee in introducing research in science at the post-graduate level following the recommendations of the

Commission of 1902, gave further boost to the scientific activity in Calcutta. Substantial donations were received from the local wealthy to institute Chairs in Physics, Chemistry, Applied Mathematics and Applied Botany. Consequently, it enabled several eminent Indian scientists to pursue an active career in research and teaching in science.

Scientists like Sir P.C. Ray who occupied the first Palit professorship in Chemistry, C.V. Raman who was the first Palit professor in Physics were part of the illustrious group. Meghnad Saha, S.N. Bose and K.S. Krishnan were other bright youngsters who had joined the group. Most of them gradually moved out of Calcutta to head new departments and institutions in science all over the country. For example, Raman moved to Bangalore to join the Indian Institute of Science in 1933, Saha went to start the physics department at Allahabad in 1923 and later returned to Calcutta university. He founded the Institute of Nuclear Physics in 1955. K.S. Krishnan served Dacca University for a while and returned to Calcutta University. He became the first Director of the National Physical Laboratory which was established in Delhi after independence. Thus these scientists spread a research tradition along with the teaching of science all over the country and took upon themselves to train a new generation of scientists. Homi Bhabha joined them when he returned from England in the late 1930's. He served the Indian Institute of Science, Bangalore for a while, but his mind was bent on building an 'outstanding

school of physics'. He stayed on to establish the Tata Institute of Fundamental Research (TIFR) which gained great impetus under his leadership and it is one of the leading research institutes of the country even today.

Thus, at the time of Independence in 1947, efforts at building an independent scientific culture had crystallised to a considerable extent. The eminent scientists had links with each other and their efforts at spreading science and building institutions of science were systematic and gradual in accordance with the needs and available resources. And in this process,it should be mentioned, they did not give up active research.

This feature of institutional development has been crucial to the spread of modern science in the country. Scientists selected to head new departments were either already known or were students of eminent scientists. Thus, they belonged to the coteries of active scientists and were constantly in contact. Later, after independence, there was a defocussing of the choice of initial leaders due to the rapid expansion of universities. This has at times brought indifferent and inefficient leaders to head new departments. Our study attempts to examine and relate the choice of initial leaders to the eventual success and failure of physics departments.

2.4 NEHRU'S ROLE IN THE DEVELOPMENT OF SCIENCE AND SCIENCE POLICY: THE POST-INDEPENDENCE PERIOD

Nehru saw in science the cure for most, if not all ills of India's underdevelopment. His interest in science dates back to

his days as a university student in England. His training at Cambridge had provided the opportunity for some contacts with the Cavendish Laboratory, where many leading British scientists in the late 19th and early 20th century worked; for example, Arthur Eddington, J.J. Thomson, Lord Rutherford and others. Such exposure had made a strong impact on his intellectual disposition. He saw in science an important means of solving man's problems.

However, many of his colleagues of the freedom movement did not share his views on the means adopted for the economic and social advancement of the country. He set up the Planning Commission in 1950 and remained its Chairman till his death in 1964. He was convinced that economic and national development were possible only through the advancement of modern science and technology. He was the minister in charge of Scientific Research and though he relinquished that portfolio in 1951 when the Ministry of Natural Resources and Scientific Research was established, he continued to serve as the President of the Governing Council of the Council of Scientific and Industrial Research till his death.

He had around him a group of eminent scientists who not only supported but also shaped his science policy. The role of Mahalanobis, S.S. Bhatnagar and Homi Bhabha deserves special mention. Nehru was intimately identified with the work in Atomic Energy. From 1954, that is, the time the Department of Atomic

Energy was established, till his death, the department remained directly under the Prime Minister's charge. His links with Homi Bhabha, Chairman of the Atomic Energy Commission and Secretary of the Department of Atomic Energy were very strong. It is said that Dr. Bhabha's name would appear on Nehru's appointment schedule for tea, dinner, etc. often, at least more frequently than was required by their official relationship. This was in spite of the fact that Dr. Bhabha was based in Bombay and not Delhi.

Outside the scope of his governmental responsibilities Nehru regularly participated in the annual sessions of the Indian Science Congress. He inaugurated or participated in almost every annual session of the Congress till his death in 1964. He thus addressed the larger scientific community directly. He used these forums to express his views, clarify his stand point and voice his apprehensions. Nehru's keen interest in science and scientific development of India is also reflected in the fact that he involved himself in key appointments in Indian science, exercised initiative or provided leadership in the inner councils of government for scientific work, and determined and defended allocations of financial resources for the development of science. (Morehouse, 1969: 496).

Nehru's strategy for the promotion of science and technology has been summarised by Rahman (1984: 88).

a) Creating social consciousness amongst scientists, by posing social problems before them and asking them to try and find

answers. This he did through various meetings that he addressed, particularly at the annual sessions of the Indian Science Congress Association, which he made it a point to attend regularly;

b) Making administrators conscious of the utility of science, by involving scientists in various committees;

c) Involving scientists in the decision-making process;

d) Using scientific knowledge in the reforms he proposed to undertake, as for example, in the use of the metric system and the preparation of an Indian Calender.

e) Giving explicit support to science and technology. He spent a great deal of time and effort in creating a base for scientific and technical research.

As a result, a number of research laboratories were established under the CSIR, different agencies like the Atomic Energy Agency, were set up; science departments in universities were expanded, and institutes of technology were created. It is understood that he even went out of his way to provide them with abundant financial resources.

f) Promoting scientific temper. Nehru believed that science could not flourish merely by creating an infrastructure without social acceptance. He therefore made considerable effort to convince the scientists about the need for popularisation of a scientific outlook. For him, "The future

belongs to science and to those who make friends with science", (Morehouse, 1969: 489).

2.5 ORGANISATION OF SCIENTIFIC RESEARCH: THE POST-INDEPENDENCE PERIOD

The country's science policy became a serious concern after Independence and the Science Policy Resolution was passed in March 1958. The plan of development involved the establishment of a network of scientific institutions as the emphasis was on rapid industrialisation with the help of scientific and technological inputs. First, those institutions which were established before independence were re-organised to meet the new requirements. Besides these, new institutions were also created to undertake research in newer areas of science and technology. For this purpose, advice from foreign scientists and institutions was taken. Thus there seems to have been considerable experimentation with respect to the organising of science in the country. The purpose behind this experimentation was to provide the new institutions functional autonomy. They were freed from bureaucratic control and were expected to undertake imaginative programmes of research. However, they were supposed to be accountable with respect to the utilisation of resources and with regard to the fulfilment of their research goals.

In the context of these, six types of research institutions were developed. (Rahman, 1984: 37-38).

1. Autonomous organisations. These organisations received their funds from the government but had freedom to frame their rules with respect to research goals and style of functioning. Thus they made their own regulations regarding recruitment of scientific and technical personnel, and procedures for the utilisation of resources etc. Institutions in this category include Council of Scientific and Industrial Research (CSIR), Indian Council for Agricultural Research (ICAR) and Indian Council for Medical Research (ICMR). These have their Governing Bodies and Research Advisory Committees to look into problems of their development.

2. Special Departments/Commissions headed by eminent scientists were created to cover new and emerging areas of science and technology. The Commissions decided broad policies and programmes. These were supported by the various government departments. The Chairman of the Commission was made Secretary to the Department and was directly responsible to the Minister concerned. The first to be established was the Atomic Energy Commission; followed by the Electronics Commission and later Space Commission. In addition to these was the Department of Science and Technology which was set up in 1970. The functions of this department were to co-ordinate research spread out under various agencies and departments and initiate research in frontier areas. Later additions are the Department of Oceanography and the Department of Biotechnology.

3. Research Institutions were also set up under the various Ministries. Such institutions existed even before Independence. They included ministries such as agriculture, health, education, industry, railways etc. These were enlarged in scope to meet the new requirements and demands.

4. Industrial R and D Establishments. Industry was encouraged to establish captive research institutions in order to meet the day-to-day requirements of production. Industry in India is both under the private and public sectors. The government provided large grants to the government-owned industry to pursue research and gave tax concessions to the private sector if engaged in research. These have not produced any encouraging results.

5. Co-operative Research Associations. The first of this kind was in the Textile Industry. Four Co-operative Research Associations were formed with the encouragement and financial support of government which met upto 50% of their expenses.

6. Private Institutions. The government provided incentives to people to invest in research by providing tax exemption if the money was to be invested for educational purposes or for research. As a result, a large number of societies, foundations and trusts were established in the country. These provided fellowships or grants for research or established educational or research institutions with specific objectives.

Out of these,the two state agencies that took off in a big way after Independence were the Council of Scientific and

Industrial Research (CSIR) and the Department of Atomic Energy (DAE). The atomic energy programme initiated in 1947, was led by Bhabha who was simultaneously the Chairman, Atomic Energy Commission, Secretary, Department of Atomic Energy, Director Atomic Energy Establishment, Trombay (later known as Bhabha Atomic Research Centre or BARC); and Director, Tata Institute of Fundamental Research till his untimely death in 1966. The other agency was the CSIR which grew rapidly with a chain of laboratories set up under the leadership of Sir S.S. Bhatnagar. The CSIR had established about 29 research laboratories by 1964 and the number went up to 44 in 1985.

Thus, one can see that Big Science received special attention after Independence. Free from teaching responsibilities, scientists working in research institutes, were able to devote their time entirely to research. They were often engaged in collaborative research. The institutions were also so designed as to provide a democratic set up in order to enhance research activity. Such a trend brought into limelight a breed of scientists who had large funds at their disposal and access to the highest levels of bureaucracy. As a result, they dominated the rest of the scientific community in the country.

2.6 EDUCATIONAL POLICY AND UNIVERSITY EXPANSION IN INDEPENDENT INDIA

After Independence, eradication of illiteracy was stressed as the leaders realised that the goals of development cannot be

achieved otherwise. Hence, a number of commissions were constituted to assist the government in re-organising the educational sector. Three commissions that have been crucial in the development of university education are the University Education Commission (1948-49) headed by Dr. S. Radhakrishnan; the Secondary Education Commission (1952-53); and the Education Commission (1964-66) headed by Dr. D.S. Kothari, an eminent physicist.

One of the major recommendations of the Radhakrishnan Commission was the establishment of a University Grants Commission (UGC). This body was to support the universities, particularly its research programmes and guide their development. The major recommendation of the Secondary Education Commission was with regard to the structure of the degree courses. The Kothari Commission evaluated the developments since Independence, identified new requirements and made specific suggestions to meet these requirements. It strongly recommended the promotion of science in universities (Rahman, 1984:29).

As a consequence, there has been phenomenal expansion in the number of universities since Independence. There were about 20 universities in 1947. But by 1960, 45 universities had been established. A boom started from the early 50's and lasted till about 1970. There were 83 universities in 1970 and in 1985 the total number of universities went up to 124, including 22 agricultural universities.

One important aspect of the education policy is that, Education was a State subject and therefore it was largely in the hands of the state governments. In December 1976, education became the joint responsibility of the Central and State government. This was part of the 42nd Amendment to the Constitution. [Government of India 1986:65]. Thus, the state governments contribute a major share of the expenditure incurred by the universities, and the UGC contributes the rest. However the UGC bears the cost of some activities in the universities like the maintenance of Centres of Advanced Study, (CAS) Summer Schools, Conferences and Seminars.

Apart from universities, the Education Policy also enabled the setting up of two other kinds of academic institutions. Under the UGC ACt of 1956, university-level institutions called as '<u>deemed to be universities</u>' could be established. An institution seeking the 'deemed' status had to apply to the UGC for recognition. On favourable recommendations from the UGC, the Ministry approves the establishment of such institutions. These institutions generally engage in higher education and research and specialise in particular areas of knowledge. In 1985, there were 15 such institutions. The Indian Institute of Science at Bangalore selected in our study is one such institution.

The second type of academic institutions is the 'Institution of National Importance'. Under this category were established the five Institutes of Technology. Some other institutions of

this kind are the All India Institute of Medical Sciences (AIIMS) at Delhi, the Post-Graduate Institute of Medicine and Research at Chandigarh and the Indian Statistical Institute at Calcutta. These institutions have been empowered to award degrees which can otherwise be done only by a university. In 1985, there were ten such institutions (Singh, 1985: 1421).

For the universities as a whole, the UGC, is responsible for co-ordination and maintenance of standards in higher and professional education. However, as mentioned earlier, higher education is a responsibility of both the state and the central governments. The UGC in India unlike its counterparts in other commonwealth countries, is both a co-ordinating and a grant-giving body.

The UGC in accordance with its role of maintaining standards has initiated several programmes. The establishment of <u>central universities</u> is one of them. There were seven such universities in the country in 1985. The main features of these universities as identified in the Report of the Benaras Hindu University Inquiry Committee is as follows:

"....Central universities should not be regarded as central merely because the Central Government finances them. They should have distinctive character of their own. The central universities should seek to supplement and not always duplicate the facilities and achievements of the state universities. <u>The State Universities, though they should function in every possible</u>

<u>way as all India institutions, have a basic responsibility to the needs of the state and the local community and sometimes these may not coincide exactly with the order of priorities and demands of other parts of the country or the country as a whole.</u> (emphasis added) However, in the case of the central universities their role and responsibility is clear -- it is to function effectively and vigorously on an <u>all India basis</u>, (emphasis added) to help build up a corporate intellectual life in the country and to further national integration. Broadly speaking, the central universities should provide courses which need facilities (in terms of staff and equipment) ordinarily <u>beyond the reach of State universities</u> (emphasis added) or for which the demand would be too small if limited only to the requirements of an individual state. There is another aspect to which we would like to refer as it has reference to the special function and responsibilities of central universities. It is well known that in our country, just as some areas are economically backward, so are some areas educationally backward; and we feel that the central universities should regard it as a part of their special function to contribute towards removal of imbalances from the academic life of our country, and take suitable action to help deserving students from educationally backward areas..." [Report of Committee on Central Universities, 1984: 4].

For the maintenance and co-ordination of research in higher education, the UGC has also introduced other specific programmes.

These programmes involve special assistance for selective departments in sciences, humanities and social sciences in various universities. The policy adopted was to concentrate on essential growth points instead of spreading resources too thinly over a wide area. The scheme of Centres of Advanced Study (CAS) was initiated in 1963-64 to encourage "pursuit of excellence" and team work in study and research and to accelerate the realisation of international standards in specific fields. This concept envisages that a centre will be able to attract students and teachers from all over the country and help in promoting academic mobility. Departments were thus recognised as 'Centres of Advanced Study' with the object of strengthening post-graduate teaching and research. The Commission provides assistance for a period of 10 years and further assistance is provided only after ascertaining satisfactory progress. The number of such centres had increased from 23 (14 in science and 9 in humanities and social sciences) in 1979 to 29 in 1985 (19 in sciences and 10 in humanities and social sciences).

The parallel scheme of Departments of Special Assistance (DSA) initiated in 1972 aims to enable certain selected departments to develop their existing potentialities and become active centres of teaching and research in selected areas. This programme is basically to provide support to the CAS programme. It aims to promote advanced study and group research effort, so that the identified department can strengthen research in one or

two thrust areas and, on the basis of evaluation, could then be recognised as a Centre of Advanced Study. The departments of Special Assistance are identified by the subject panels, keeping in view the on-going research activities and their achievements. The recommendations of the panels are placed before the Standing Committee on Centres of Advanced Study/Departments for Special Assistance which, after screening, recommends the departments for assistance. Expert committees are then constituted which examine the proposals in detail. Their reports are taken into consideration by the Commission before a final decision is made. In 1985, there were 92 such departments, 65 in science and 27 in humanities and social sciences. (UGC, Report for the year 1984-85: 30-32).

Other schemes are the <u>Departmental Research Support Programme</u> under which 49 departments in science, humanities and social sciences received assistance; the strengthening of Infrastructure in science and technology etc.. The basic objective of the latter scheme is to get the best out of the already available good academics by providing such inputs as will usher in imparting good quality post-graduate education and research of high standard. Through a special committee called 'COSIST' this grant is given to university departments/colleges on a highly selective basis. 31 science departments and 7 departments of engineering have merited the COSIST support during

However, there is considerable overlapping among all the

schemes mentioned above. A department therefore can attract funds from more than one scheme (UGC Report for the year 84-85:32).

Besides these, the Commission also provides assistance to selected individual, group or departmental research projects (UGC Report for the year 84-85:34 & 35).

Thus, we find that the UGC has been making efforts consistently to resolve the differential status of research in universities, largely generated by the educational policy of the country.

2.7 SCIENTIFIC AND TECHNICAL MANPOWER IN INDIA

From the above discussion, it is evident that scientists in India work in various types of scientific institutions. In accordance with their affiliation, their duties and obligations vary. The estimated scientific and technical manpower in 84-85 was 25.61 lakhs which is acknowledged as the third largest in the world. However, it has to be noted that not all of them are engaged in research and development activities. Personnel employed in institutions engaged in scientific and technical activities constitute only 2.22 lakhs. Again, only 35% of this figure constitute scientists directly engaged in research and development activities. 33% provide auxiliary support: Staff like laboratory assistants, technicians etc. and the remaining

32% take care of the administrative needs of these institutions (DST - R & D Statistics, 1984-85:iv).

This active scientific and technical manpower is distributed over 124 universities (including 22 agricultural universities) 15 institutions deemed to be universities; 10 institutions of national importance, 44 CSIR laboratories, and other research institutes established directly under the various ministries and agencies of the Government.

However, the assessment of scientific productivity in terms of a cost-benefit analysis has been far from encouraging and has been bothering the bureaucrats, politicians and others who make highly negative statements about the health of science in India. Investigations to identify the problems, weak links in the policy, the lacuna in the relationship between science and the larger society, etc. are extremely important and need urgent attention. Such investigations would help in providing suggestions to modify and organise science in such a way as to improve the accountability chart.

2.8 CRISIS IN SCIENCE : SOME ISSUES AND PROBLEMS

Science grew very rapidly in terms of institutions, financial investment and personnel employed, primarily under the patronage of the state after Independence. This quantitative growth has been at the cost of quality, especially in the case of science in the universities. Several eminent and active young scientists were drawn away from the universities to the research

institutes propagating 'Big Science' offering them higher salaries and better perquisites. Thus, an effective process of training younger scientists especially in research has suffered significantly. Further, some of these eminent scientists have been drawn away from active research too, when they were inducted into the bureaucratic realms of organising science in the country. These eminent scientists advocated research in the frontier areas of science and technology so that Indian science can compete at the international level. Most of these areas require high financial investment and sophisticated technology and have little direct relevance to the problems faced by the Indian society at large. Consequently, a schism has emerged between these elite institutions practising Big Science and the other scientific institutions of the country. Differentiation and discrimination have also emerged among scientists working in elite institutions and the other scientific institutions.

It should however be noted that research institutes established after independence, whether under the CSIR, ministries or various science and technology agencies are all what one may call 'mission-oriented'. They specialise in certain areas and have specific goals to obtain. Scientists in universities on the other hand pursue research with greater freedom with respect to the areas and problems chosen. However, with the weakening of the 'research culture' in universities, it

has become difficult for scientists in universities to grow as an autonomous scientific community.

Added to this are problems generated by the inconsistent policy on higher education. A large number of universities are largely under the control of the state government and several state governments encourage the regional language as the medium of instruction even for higher education. This has made the task of UGC for co-ordinating standards a very difficult one. The two movements, the propagation of Big Science directed towards international integration advocated by the 'eminent elite scientists' on the one hand and the passionate involvement of the politicians of the present day in issues of regionalism and of relevance of science to the country's needs have become irreconcilable. Crises therefore have emerged not only among the different scientific institutions but also amongst the scientific community working in different institutions varying in goals and obligations. A total reconsideration of science policy and educational expansion may be essential to resolve such a crisis.

CHAPTER III

THE RESEARCH PLAN: LOCATION OF THE FIELD AND SOME HISTORICAL DETAILS

This chapter locates the research field . In line with the specific objectives of the research problem as explicated in chapter I, we outline in the first section of this chapter the methodology adopted in selecting the institutions and scientists for the present study. Details of the research technique used for data collection, the nature of data collected and the duration of the field work are then provided. The second section of this chapter gives some historical details of the four universities and seven physics departments selected for this study.

SECTION I

3.1 LOCATION OF THE FIELD

From the discussion on the development of modern science in India, it is evident that scientists primarily work in two different kinds of institutions:

i) the exclusive research institutions, a majority of them being government organisations and

ii) academic institutions that include universities, colleges etc. of which some are privately funded, some, in fact, the

majority, funded by the respective state governments and a few directly by the central government.

These two types of institutions vary considerably in their structure, goals and functioning. As it is impossible to attempt a meaningful study of fragmentation involving scientists from various kinds of institutions in a single project, we wish to restrict the study to only one kind of institution. The available literature on the scientific community has almost always concentrated on the elite scientists practising 'Big Science' in the advanced research institutes. A large majority of scientists who constitute the scientific and technical manpower in the universities have received scant attention because they are 'low producers' of 'Big Science'. Scientists in universities have therefore been assigned the lower rungs in the stratification of science in the country. It seems a worthwhile endeavour to study the university scientists -- peripheral scientists from one point of view - in a country whose science in itself is regarded as peripheral in the context of international science.

However, since universities have several departments and hundreds of scientists working in them, we decided to limit our study to scientists from only one discipline so as to give a sharp focus to it. We chose PHYSICS for two reasons: one, this discipline was one of the earliest pure sciences to be introduced

in the country and almost every university in the country has a department of physics. Two, physics has throughout remained the heavily funded among the science disciplines. Though research in physics began in the early 1920's, it took off in a big way mainly after Independence. Large funding has always been related to 'Big Science' and fragmentation among scientists is always in relation to doing 'Big Science'. Therefore, in a study on fragmentation, it seemed appropriate to choose the discipline of physics. It was felt undesirable to further restrict the study to a specific research area in physics because it would have resulted in studying too small a group in a very small number of universities or a large scatter, for which field work would have been difficult.

Having decided on the discipline and the kind of institution, the question then is how to restrict the choice of universities and physics departments. As discussed in the earlier chapter, the UGC had introduced several programmes to strengthen research in universities, such as CAS, DSA etc.. As such, physics departments vary in status from one university to another. In addition, universities too are of different types. At least four types could be discerned: (i) State/Unitary (ii) State/Affiliating (iii) Central and (iv) Deemed to be University.

Given this diverse nature of universities and physics departments, we decided to select scientists from universities, who would to some extent represent the following :

(a) Different types of university affiliation

(b) Physics departments varying in status

(c) The diverse socio-cultural environment of the country.

In 1985, when we began the research there were seventy five State/Affiliating universities, eight State Unitary universities, seven Central universities and fifteen Deemed to be universities. As for the status of physics departments, two were designated as Centres of Advanced Study, eight were receiving Special Assistance, four obtained funds under the Departmental Research Support Scheme and six came under the Science and Technology Infrastructure Development programme of the UGC.

In short, we aimed to study scientists from four different types of universities and physics departments varying in category and status. We systematically matched the types of universities with the status of physics departments. Giving due consideration to the diverse socio-cultural environment in which the universities are located, we identified seven physics departments from four different types of universities. Our sample therefore is stratified as it represents scientists belonging to physics departments varying in status and is purposively chosen as departments were so selected as to represent different types of universities and diversity in the socio-cultural context of the country. These four universities represent four different types of universities found in India. Though statistically speaking, their physicists cannot be presumed to represent the entire

physics community of the country, yet it is hoped that a study of all the physicists of these seven departments will give us a fairly adequate understanding of stratification among physicists and their fragmentation in the context of their institutional affiliation.

3.2 SELECTED UNIVERSITIES AND DEPARTMENTS

The four universities included in this study are: (i) M.S. University of Baroda (ii) University of Madras (iii) Indian Institute of Science, Bangalore and (iv) Delhi University. The differences among these universities and the status of physics departments in them are as follows:

(i) M.S. University, Baroda

This represents a State/Unitary type of university with a single campus and no affiliating colleges. Its programmes range from undergraduate teaching to doctoral research in almost all its departments. The university has two physics departments, one under the Faculty of Science [Physics] and the other, under the Faculty of Technology [Applied physics]. Neither of these two departments had any special status under the UGC programme.

(ii) University of Madras

This is one of the first three modern universities to be established in the country and represents a State/Affiliating type. The university has three physics departments that constitute the 'School of Physics'. They are (1) the department

of Biophysics and Crystallography (2) the department of Theoretical physics and (3) the department of Nuclear physics. As for their status, the department of Biophysics and Crystallography was recognised as a Centre of Advanced Study from the early 1960's till the mid 1970's when it was de-recognised as such by the UGC. At the time of field work, this department was receiving funds from the UGC under the Special Assistance programme. The remaining two departments received special funds from the UGC under the Science and Technology Infrastructure Development programme (COSIST).

(iii) **Indian Institute of Science, Bangalore**

This represents an institution 'Deemed to be a University'. Physicists in this institute are located in a number of centres. For our purpose, we selected the Molecular Biophysics Unit. This unit has been recognised by the UGC as a Centre of Advanced Study. Our choice has been governed to some extent by the fact that Dr. G.N. Ramachandran who was the founder of the Biophysics and Crystallography department of Madras University, also established the Molecular Biophysics Unit of Indian Institute of Science (I.I.Sc.). Dr. Ramachandran left Madras University in the early 1970's and joined I.I.Sc. This period coincided with the de-recognition of the Madras department as a CAS and the development of Molecular Biophysics Unit in Bangalore. The links seemed worth pursuing.

(iv) **Delhi University**

This represents a Central University. The department selected here is the department of Physics and Astrophysics which was assigned the status of CAS in physics by the UGC.

The target respondents from these seven departments and four universities were 150 in all. Our aim was to interview all of them. However, owing to certain limitations such as accessibility (some scientists were away on sabbatical leave during our field work), refusal to give interviews and institutional constraints on time for the researcher, only 87 physicists could be finally interviewed.

3.3 TECHNIQUE AND DATA

The interview schedule was used as the main tool for data collection. This method allowed the investigator to introduce variations when the occasion so demanded. The main areas on which data were collected are as follows:

i) Educational background and career profile of scientists

ii) Teaching duties, research interests and productivity of scientists

iii) Internal and external communication patterns of scientists - academic and extra-academic linkages

iv) Patterns of recruitment and promotion, criteria involved and incentives offered by the respective institutions

v) Membership of respondents in academic associations, scientific societies and other committees related to science

vi) Awards, rewards obtained by the scientists.

However, these were only guidelines and the interviews yielded a great deal more qualitative data than anticipated. Primary data thus collected were supplemented with material obtained from sources such as annual reports and other relevant documents related to the history of the universities and departments. Casual conversations with students, participation in departmental seminars etc., also provided useful data.

Field work was done in the years 1986-87. In all, actual field work took about seven months. It was however not undertaken at a stretch, but was interspersed with necessary breaks, especially while moving from one university to another. The main limitations of the data so collected are the extensiveness and spread of the selected scientists which implies a loss in intensiveness and detail.

3.4 COMPOSITIONAL NATURE OF THE SAMPLE

At this juncture, we wish to provide some idea about the break-up of the faculty interviewed in the seven departments according to their grades. It was difficult to obtain reliable data on the sanctioned strength of faculty members in the departments chosen. So we decided to interview all the existing members of the faculty of these departments. But owing to reasons already given, we could interview only 87 physicists.

TABLE 3.1

COMPOSITION OF FACULTY STRENGTH

UNIVERSITIES		REAL SIZE P	R	L	R.A.	TOTAL	SAMPLE SIZE P	R	L	R.A.	TOTAL
BARODA	(X)	3	10	12	0	25	3	7	4	0	14
	(Y)	3	11	1	0	15	2+1*	8	1	0	11+1**
MADRAS	(A)	7	3	6	0	16	5	3	5	0	13
	(B)	3	1	3	2	9	3	1	3	2	9
	(C)	2	2	2	1	7	2	2	1	1	6
BANGALORE		7	3*	0	0	10	6	3*	0	0	9
DELHI		29	17	6	0	52	14	8	2	0	24
TOTAL		54 (40%)	47 (35%)	30 (23%)	3 (2%)	134 (100%)	35+1** (41%)	32 (37%)	16 (18%)	3 (4%)	86+1** (100%)

* The different grades of this department are Professor, Associate Professor, Assistant Professor and Lecturer. There were no Associate Professors and the three members included in the Readers column refer to Assistant Professors.

**In this department, in addition to the faculty strength, an ex-head, a retired professor was also included in the sample. Hence our study has 87 respondents.

P - Professors
R - Readers
L - Lecturers
R.A. - Research Associates

However, these physicists were neither purposively or randomly selected. Table 3.1 presents the compositional nature of the faculty strength in the seven departments, in terms of both the existing size and sample size.

Some clarifications are in order to read the figures in Table 3.1. As enunciated earlier, M.S. University of Baroda has two physics departments: physics and applied physics. We would henceforth refer to them as X and Y of Baroda in that order throughout our analysis. Similarly the three departments of physics in Madras University, namely, Crystallography and Biophysics, Theoretical physics and Nuclear physics would be referred to as A,B and C of Madras hereafter. As the remaining two universities have only one department each, they would be referred to as Bangalore and Delhi.

Before proceeding to a detailed analysis of the data collected, let us look into some historical details of the selected universities and departments. These constitute an essential base in our attempt to understand the functioning of university physicists within a particular kind of institutional set up.

SECTION II

3.5 M.S. UNIVERSITY, BARODA

History : While colleges and other educational institutions had been established in Baroda from 1881 onwards, it was only in 1949

that a university was established when the Maharaja at that time, Sir Pratap Singh surrendered his powers and agreed to merge his princely state of Baroda with the state of Bombay. Two state trusts of Rs.1 crore each were created and one of the chief beneficiaries of the income from these trusts was to be the new university in accordance with the wish of his predecessors, especially Maharaja Sayaji Rao who since the mid 1920's had planned for a university at Baroda. Thus Maharaja Sayaji Rao University of Baroda (M.S. University for short), came to be established in the year 1949 as a unitary residential university.

Gujarat had been open to sea traffic through its ports of Surat and Cambay till the nineteenth century, when Bombay reduced the significance of these ports. While many Gujaratis migrated to foreign countries, especially to Africa, their trading connections made Gujarat one of India's earliest sites for industrialisation, especially the textile industry. But it should be noted that many Ahmedabadis became modern industrial entrepreneurs without abandoning their traditional life styles and values typical of the merchant castes of Western India. While the commercial class of the state was interested in modern education, the cultural conservatism of the state had endowed it with an enthusiasm for the regional language (Gujarati) or the official language (Hindi). The impact of English culture and education therefore was minimal in Gujarat. Thus the concerns of those interested in a cosmopolitan and high quality education

were to some extent at variance with the concerns of those interested in more plentiful and accessible education in the regional language.

As for the immediate environment of M.S. University, Baroda has become one of western India's most important industrial cities following Bombay and Ahmedabad. The main industries in the city are chemicals, chemical products, drugs and pharmaceuticals. The Rudolphs (1972) have made an interesting study of the process of compression and parochialisation affecting the quality of education and the administration of M.S. University. Using various indicators of parochialism – cosmopolitanism continuum, they have analysed the impact of university's outer environment, represented by community, regional and populist pressures in transforming the inner environment of the university.

The ratio of academics to non-academics is lower in the syndicate of state universities through which the Vice-Chancellor functions. M.S. University was established with local patronage (Maharaja's Trust) and continues to depend on the external environment for funds. In other words, the wealth and professionalism of the local community significantly affects university matters and administration.

3.5.1 Department of Physics

Establishment:

The department of physics was instituted in the year 1949,

that is, the same year as the inception of the university. It was located in the Faculty of Science. Dr. Apte who was a student of Sir C.V. Raman was the head initially (just for a year or two), but it is understood that the department actually developed under the headship of Dr. Gogte. Dr. Gogte, educated in England, had a doctorate degree in the area of Heat and Thermodynamics. He had an outstanding career with interest primarily in experimental research.

The initial years, some of his students say, were very tough and he had to fight for each and every little facility for the department. The early recruitment was mainly directed towards taking care of the necessary duties of the department -- the undergraduate classes. Dr. Gogte, it is said had brought into the department excellent teachers, most of them from the colleges, but none of them had a doctorate degree. This, some respondents feel inhibited the development of a research culture in the department from the beginning. These teachers on the one hand did not have a research degree and on the other had too heavy a teaching load preventing them from registering for one. Besides, it is also said that Dr. Gogte (who was head for 12-13 years, till about 1962), was too amenable a person which affected further recruitment in the department. Yielding to pressure from university authorities and other local patrons, teachers with varied research interests were recruited. This posed problems

for the strengthening of research laboratories, as direction to department growth became diffused.

The successive heads too, it is learnt, did little to salvage the situation. The main area of interest of some senior professors was spectroscopy, and though they did remain heads for sufficiently long periods, especially Professor M.M. Patel, they were able to do little for the department. They did have small groups around them, mainly graduate students, but spent more time consolidating their positions. Later though some members made efforts to improve the department, a change in perspective was difficult as the department by then was about 20 years old.

Teaching

The department started with a three year B.Sc. programme and gradually developed the two year M.Sc. degree and the doctoral programmes. Some faculty members of this department were initially catering to the needs of the engineering college of the university. As it was becoming unmanageable, the need for another department in the Faculty of Technology was fulfilled in 1969 and the department of Applied Physics was established.

Research

The department ofphysics is primarily a teaching department. However, the faculty do engage in some form of research. The areas of interest at the time of field work were primarily experimental in nature. They include X-ray Crystallography, Heat

Transfer, Atomic and Molecular Physics (theoretical) and some other experimental problems in Solid State physics.

3.5.2 Department of Applied Physics

Establishment

This department is located in the Faculty of Technology which is about 5 Km away from the Faculty of Science. Initially, (from 1969) the physics department in the Faculty of Technology and Engineering was functioning under the overall supervision of the head, physics department, Faculty of Science. The department became statutorily independent only in 1973.

The first head of this department was Professor R.V. Joshi. He was earlier a faculty member of the physics department in the Faculty of Science. He went to University of Leeds, U.K., in 1955 and obtained his doctoral degree in 1958. On return, he was appointed as senior lecturer in 1958, promoted to the post of reader in physics in 1962 and appointed professor of physics in the Faculty of Technology and Engineering in 1966. He took over as the head of the newly instituted Applied physics department in the year 1973 and continued to work in that capacity till his retirement in 1985.

Teaching:

The faculty members mainly take care of the core courses of the engineering students. The department also has a full-fledged two year M.Sc. programme in Applied physics since inception

(1973). Besides, there are research students in the Ph.D. programme.

Research:

The first head Dr. Joshi was continuously involved in research work. He thus created a research culture from the beginning. His earlier research work was in optical and related properties of solids. He developed a research laboratory in that area and guided students for the Ph.D. degree. The investigations were mainly in the field of Luminescence in solids and other related areas like Colour Centres in Solids, Dosimetry etc.. Other areas of research pursued were

a) Crystal growth and Surface Topography

b) Ultrasonics

c) Liquid Crystals.

3.6 UNIVERSITY OF MADRAS

History

The University of Madras was incorporated by an Act of the Legislative Council of India dated 5th September,1857. Organised on the model of the London University of the day, the university had limited objectives, it was to be merely an examining and affiliating body.

The University Act VII of 1923, was a significant break for the growth of Madras University. This Act conferred on the university a large measure of autonomy, because the former provision which required the government's approval for all

changes in the rules and regulations of the university was abrogated by this Act. Besides, the University Act of 1923 made the principle executive head, the Vice-Chancellor, a whole time officer of the university. Till then, the Vice-Chancellorship was regarded as an honorary post to be filled by a prominent man who would attend to the affairs of the university in his leisure time. The progress of the university was prominently seen in the creation of new departments of teaching and research on the one hand and in the expansion of the existing ones on the other. Upto this time, all postgraduate teaching was done in the constituent colleges affiliated to the university. Following the Act of 1923, the disciplines to get attention first were the different languages. In 1925, the department of Indian Economics attained a permanent status. In the following year, the faculty of commerce was organised along with the department of Indian History & Archaeology.

Though a recommendation of the Board of Studies urged the need for the opening of a research department in physics as early as 1928, it was not until 1951, that the department of physics was established (Pillay, 1957: I: 17).

The Vice-Chancellor is a full-time authority and head of the university. He functions through the syndicate, however taking the advice of all the councils (syndicate, senate and academic council). Madras University has had some eminent educationists and scientists as Vice-Chancellors. Significant among them was

Sir A. Lakshmanaswamy Mudaliar (1942-69) during whose period the university attained significant heights and many firsts. In 1969 there was a crucial turn to university policy when Thiru N.D. Sundara Vadivelu took over as the Vice Chancellor. This period coincided with the change in the ruling party of the state government. Congress lost the election and the regional party Dravida Munnetra Kazhagam (DMK) came into power. Along with it came the strict adherence to the policy of reservations and the Brahmin Non-Brahmin discrimination. This significantly affected the recruitment of faculty and staff and admissions of students to the various programmes.

3.6.1 Department of Crystallography and Biophysics

Establishment:

In the early 1950's, Dr. Sir A. Lakshmanaswamy Mudaliar, Vice-Chancellor of Madras University, wrote to Professor C.V. Raman inviting him to head the new research department in physics that had been proposed for the university. Sir C.V. Raman, it is said, replied, but strongly recommended Dr. G.N. Ramachandran for that position. Dr. Ramachandran had completed his doctorate under the guidance of Sir C.V. Raman at Bangalore and had been to the Cavendish Laboratory in U.K., for two years under the 1851 Exhibition scholarship. On his return, he had joined as an assistant professor in the department of physics at the Indian Institute of Science, Bangalore, and had started working on

experiments to study the perfection of crystals using polarised X-rays. Sir Lakshmanaswamy Mudaliar accepted the recommendation and appointed Dr. Ramachandran as a full professor and head of the physics department in the year 1951, when he was not even 30 years of age (Srinivasan, 1982: 467-473). The other members of the faculty at the time of the inception of the department were Dr. Alladi Ramakrishnan as a reader (a theoretical physicist) and Sri K.S. Chandrasekaran as a research assistant (Pillay, 1957: II: 204-205).

Teaching

Initially the department had a one year post-graduate programme leading to a Masters degree in two branches - a theoretical course on Statistical Mechanics and an experimental course on X-ray Crystallography. The doctoral programme was also simultaneously introduced, for which the number of students registering every year steadily increased. At that time, many of those who had taken their doctorate from that department continued their advanced research as post-doctoral fellows in the same department. In 1977, a two year M.Sc. physics course was offered. The M.Phil programme was also introduced in the same year. In 1981, an inter disciplinary M.Sc. Branch IIIA in Biophysics was started (Shanmugasundaram, 1983: 129).

Research:

Since the department was new, Dr. Ramachandran had almost complete freedom to develop the department the way he liked.

Having been influenced by Professor Raman and Sir Lawrence Bragg, Crystallography formed the main focus of his initial plan of activity. He soon set up an X-ray laboratory. Within almost two years of the establishment of this department a major scientific breakthrough emanated from this laboratory, which was the triple helical structural model of collagen. Though there was a theoretical group also in the department, it was the experimental group led by G.N. Ramachandran that was dominating the scene.

Ramachandran's work was published in 1954 in NATURE and it brought international recognition to him. There was no looking back after that and in 1962 when the UGC introduced the scheme of 'Centres of Advanced Study', the Madras centre was recognised immediately (1963) for Crystallography and Biophysics. An international symposium on Crystallography and Protein structure was organised. It may perhaps be mentioned that this was also the time when the Indian National Science Academy (INSA) realised the need for setting up a National Committee for Crystallography of which Professor G.N. Ramachandran was appointed Chairman. For some years, almost annually, national seminars were held in Madras. Though the centre was recognised for Crystallography and Biophysics, it is interesting to note that over the years it has been Crystallography that has come to stay.

In the early fifties at Madras, the trial molecular models were built using 'ribs of cocoanut leaves' to represent the virtual bonds in polypeptide chains. Universities in India, did

lack good facilities and funds, but never brain power. The achievements of Professor Ramachandran is said to be a shining example. S.K. Mitra writing about twenty-five years of physics in India states: "We find that it is really difficult to name any single piece of work done in these 25 years which sort of stands out, except probably in Biophysics, namely the structure of collagen and investigations on bio-molecules by G.N. Ramachandran at Madras. One would also notice that over this period the prominence of single individuals has been somewhat lost and there is an emergence of viable groups each specialising in a particular area of physics". (Mitra, 1972: 143).

Dr. Ramachandran was able to build the department due to the constant support he received from the then Vice-Chancellor of Madras University -- Sir A. Lakshmanaswamy Mudaliar who gave him complete autonomy to develop the department. However the change in Vice Chancellorship and the perspectives and policies of the university had a significant impact on the further growth of the department. It is said that in 1970 (a year after N.D. Sundara Vadivelu had taken over as the Vice-Chancellor), there was some recruitment for the post of a Technical Assistant in the department of physics. G.N. Ramachandran then was the Chairman of the selection panel. It is learnt that the selection made at the department level was vetoed by the Vice-Chancellor, proposing the appointment of a non-Brahmin candidate to that position, as there were already too many Brahmins in the department.

Professor Ramachandran, it is learnt, immediately resigned as he felt that his professional expertise was insulted. He then got in touch with Prof. Satish Dhawan, the then Director of Indian Institute of Science, Bangalore, enquiring about an opening for him, who was only too willing to have G.N. Ramachandran back. What was Madras' loss became a gain for Bangalore. It is learnt that Professor Ramachandran while leaving Madras also took along with him a number of faculty members and students whom he had trained.

Research activity continued with the remaining members, but the UGC on evaluating the work during the mid 1970's was unsatisfied and de-recognised the department as a CAS. It however, continued to provide grants under the Special Assistance programme.

Other Activities:

The department has been organising summer, winter schools, seminars, symposia and conferences fairly regularly. These were more frequent in the initial years when Dr. G.N. Ramachandran was a part of the department. However, in the late seventies and early eighties a few international conferences have also been held and the proceedings brought out in the form of books. The department also boasts of having scientists of national and international repute visiting them and giving lectures. In the initial years the well-known scientific journal 'Current Science' was being edited by the faculty. It is now edited and published

by the Indian Academy of Science, Bangalore. In 1978, the Department of Science and Technology (DST) supported the setting up of a National Centre for Crystallography (NICRYS) under the NISSAT programme of DST with Prof. R. Srinivasan as its Hony. Director. The NICRYS at Madras is probably unique and is the only one of its type in India dealing with hard-data service facility. The Data Centre's services are utilised by the scientists of neighbouring countries such as Bangladesh, Malaysia etc., besides the Indian scientists. A quarterly newsletter is brought out by the NICRYS centre to keep crystallographers informed of notes and news relating to activities of the centre.

3.6.2 Department of Theoretical Physics

Establishment :

The research areas initiated in the physics department of Madras University were X-ray Crystallography, Molecular Biophysics and Theoretical physics. The former two were under Professor Ramachandran and the latter under Dr. Alladi Ramakrishnan who was then a reader in the department. But Dr. Alladi Ramakrishnan left the department in the late 50's to join as professor and head of the newly opened physics department at Madurai university. Dr. Mathews joined the department in 1959 as a reader, who had completed his doctorate under Dr. Alladi Ramakrishnan in 1956. Given the situation, "there was some problem in getting available assistance from the UGC etc.,

through the set-up of the existing department" to quote a respondent. It is learnt that Dr. Mudaliar, the then Vice-Chancellor, in his wisdom decided to split the department in order to enhance the growth of both the groups. Thus the department of Theoretical physics was born in 1964. Dr. P.M. Mathews was made professor and head of the new department and was given charge to steer the department with the help of a reader and a lecturer.

Teaching :

A post M.Sc. diploma course in theoretical physics was offered from 1969 to 1975 and the regular two year M.Sc. physics programme was initiated in the year 1976. In 1977, M.Phil. was offered both as part-time and a full-time programme. Doctoral students were however registered right from inception. By 1983, the department had produced 30 Ph.Ds and 15 M.Phils.

Research :

The department is engaged in active research in various areas of theoretical physics. Some areas of research are Quantum Mechanics, Relativistic Wave Equations, Nonlinear problems and Solutions, Classical and Quantum Field theory, General Relativistic Effects, Quark Matter etc. This department along with the department of Nuclear physics of the same university receives funds from the UGC under the COSIST (Committee for the Strengthening of Infrastructure in Science and Technology)

Other Activities :

The department had hosted a national conference on theoretical physics in 1970.

3.6.3 Department of Nuclear Physics

Establishment :

This department was established in 1969 with Dr. V. Devanathan as reader-in-charge. Dr. Devanathan was trained in Madras University and was teaching Nuclear physics in A.C. College of Engineering which was under Madras University. When the need was felt to do research in nuclear physics, it was found to be impractical in the college of engineering and necessitated the establishment of an independent department. As by now, there were already two departments of physics, a third one -- Nuclear physics was constituted in 1969 and the three departments came under what is now known as the 'School of Physics'. Dr. Devanathan was later promoted as professor and continues to be the head. The department however expanded gradually and has faculty members interested both in theoretical and experimental areas in Nuclear Physics.

Teaching :

The department offers a two year M.Sc. programme in Nuclear physics and an M.Phil. course since 1976-77. Initially it was a joint programme conducted by all the three departments, but from 1980 onwards it runs as an inter-disciplinary M.Sc. Br. III C

physics course with the department of theoretical physics under the School of Physics. The Ph.D. programme was introduced at the time of inception of the department.

Research :

The key research areas pursued by the faculty members are (1) Elementary Particle Interaction with Nucleii (2) Heavy Ion Reaction (3) Band Structure Calculations (4) Positron Annihilations in Solids (5) Mossbaur Effect (6) Thin Film techniques (7) Positron Life Time studies etc.. Faculty members have also been interested in Instrumentation, designing and fabricating instruments necessary for their research purposes. For the COSIST proposal, the department had requested funds to introduce a new specialisation in their M.Sc. course, i.e., Radiation Physics in collaboration with the Reactor Research Centre, Kalpakkam. It was to have three papers : Basic Radiation Physics, Applied Radiation Physics and experiments in Radiation Physics and detection (Annual Report 84-85 and 85-86) which was yet to be sanctioned at the time of field work.

Other Activities :

The department has been organising workshops, national seminars and symposia regularly. All the three departments of physics have been very active. They have distinguished visitors giving seminars, lectures, etc., have been organising national/international seminars, symposia and also summer, winter

schools regularly. The departments have academic autonomy but are together for administrative purposes.

3.7 INDIAN INSTITUTE OF SCIENCE, BANGALORE

History :

Jamsetji Nusserwariji Tata (1839-1904) towards the end of the nineteenth century was convinced that the future progress of this country depended on research in science and engineering. Therefore, he created an endowment in September 1898, to establish a university of science. It is interesting to recall that the original plan of Jamsetji included scientific and technological education; medical and sanitary education including research in bacteriology; studies in philosophy and education (including methods of education), ethics and psychology; Indian history and archaeology; statistics, economics and comparative philology. He envisaged this university as destined to promote original investigation in all branches of learning and to utilise them for the benefit of the country.

He constituted a provisional committee to prepare the required scheme for the setting up of the Institute. On 31st December 1898, a draft prepared by the committee was presented to Lord Curzon, the Viceroy designate. The Secretary of the State for India requested the Royal Society of England for an expert view, and the Royal Society requested William Ramsay (later a Nobel Laureate) to help. He made a quick tour of the country and

reported that Bangalore was a suitable place for such an institution. In order to finalise the scheme, Lord Curzon took the advice of Orme Masson of the University of Melbourne and Lt. Col. Clibborn of the College of Engineering, Roorkee. The Clibborn-Masson Committee recommended Roorkee as a suitable area. However, on the initiative of the Dewan Sri R. Seshadri Iyer, the government of His Highness Shri Krishnaraja Wodeyar IV, the Maharaja of Mysore came forward with an offer of 372 acres of land, free of cost, in Bangalore and promised other necessary facilities. Thus the original scheme of Jamsetji Tata became a tripartite venture with the association of the government of India and the government of the Maharaja of Mysore.

The detailed report that emerged recommended that "the Institute be devoted to experimental science and that it aim at training students in experimental methods; carrying out original research and discharging functions of an accepted authority and referee on all scientific problems arising within its own domain" (Indian Institute of Science, 1984:10). Early in 1911, the Maharaja of Mysore, laid the foundation stone of the Institute and on 24th July the first batch of students was admitted to the departments of General and Applied Chemistry under Norman Rudolf and Electro-technology under Alfred Hay. Within two months, the department of organic chemistry was also opened.

The Institute's work in the early years was focused on utilising indigenous materials to benefit industry. The Mysore Soap Factory and the Sandalwood Oil Factory were among the early beneficiaries. The origin of the Hydrogenation industry can be traced to the work done by the Organic Chemistry department. Besides, the Central Food and Technical Research Institute at Mysore, Lac Research Institute at Ranchi and National Aeronautical Laboratory in Bangalore are said to be the direct offshoots of the Institute (Lala,1981:38).

One interesting feature of this institute is the choice of priority of subjects that were introduced. Probably because of its aim to benefit the industries around, departments of Organic, Inorganic and Physical Chemistry were introduced in 1911 -- the year of actual inception of the institute. So was Electrical Engineering. Physics was established as a separate department only in the year 1933 with Sir C.V. Raman as its first Chairman who continued in that capacity till 1948. He was also the first Indian Director of the Institute (1933-37) after M.O. Forster. Raman set the tradition and provided leadership for the pioneering work of the physics department in Optics and Spectroscopy. His tradition has been continued both in experimental and theoretical research over a wide gamut of areas, linked to some extent by a common thread of Condensed Matter physics. However, a number of specialised centres have come up

in the institute, and physicists are located in several departments and centres all over the Institute.

With the establishment of the UGC by the government of India in 1956, the institute came under its purview and is one of the 15 'Deemed Universities'. From inception, the institute has been having eminent scientists as Directors. It is one of the institutes in the country that can boast of having a large number of Bhatnagar awardees, fellows of the Science Academies and recipients of other distinguished national and international recognitions.

The institute has two Deans -- one for Science and the other for Engineering and five Chairmen of Divisions. The President of India is the 'Visitor' since Independence. The Council continues to be the principal authority governing the institute. It consists of the Director, the two Deans and 21 other members which includes educationists, bureaucrats, industrialists and even Members of Parliament. The Council is assisted in the formulation of the academic policies by the Court. The Court consists of members of the Council, the professors of the institute and 21 other members, Representatives from Indian universities, nominees from the Councils, educationists, industrialists and bureaucrats constitute the 21 members of the Court.

3.7.1 Molecular Biophysics Unit

Establishment :

This is the youngest department of our sample, having been established only in 1971 under the leadership of Prof. G.N. Ramachandran. The genesis of this unit is in a way accidental. The background to some extent has already been discussed while noting details of the history of the Crystallography and Biophysics department of Madras University. Prof. G.N. Ramachandran while leaving Madras, also brought along with him to Bangalore a number of faculty members and students whom he had trained to start the new department. Thus a whole group already well trained formed the new department and V. Sasisekharan one of Ramachandran's first students, took charge as Chairman of the department in 1972.

Teaching :

The department has only the doctoral programme for whom some courses are offered. In 1985, it had 45 research scholars working with 11 faculty members.

Research :

This is the major activity of the department. The group under Prof. Ramachandran's guidance has been very active. Structure, Conformation and Interaction of biomolecules are being investigated with the objective of explaining biological activity in molecular terms. Both theoretical and experimental studies are pursued simultaneously. Research publications have been

regular and in journals of repute. Within a span of 15 years, the department has been able to make its place significant in terms of research in Molecular Biophysics at the international level.

Professor Ramachandran however of late, is little associated with the department. He has been made the INSA Einstein Professor of Mathematical Philosophy of the institute.

3.8 DELHI UNIVERSITY

History :

This university owes its establishment to the era of university reforms which followed the publication of the Report of the Calcutta University Commission. The Commission recommended that all the universities in India, along with Calcutta university, should be reorganised emphasizing on decentralisation and be unitary, residential and teaching in nature. Following this, Punjab University in Lahore began to reshape its character. The three existing colleges in Delhi, St. Stephens founded in 1882, Hindu College founded in 1899 and Ramjas College founded in 1917 faced a problem, as they were affiliated to Punjab University. Consequently, a need was felt to have an independent university for the students of the capital.

The University of Delhi was incorporated as a unitary teaching and residential university by an Act of the Central Legislative Assembly in February 1922. The university made a

modest beginning with three colleges, 750 students and a grant of Rs.40,000 from the government. Two faculties viz. Arts and Science were established in the year 1922, and the Law Faculty came into existence two years later. Dr. Hari Singh Gour, a distinguished Barrister-at-Law from Nagpur was the first Vice-Chancellor. The Vice-Chancellorship at that time was an honorary and part-time office. The very existence of the university was threatened soon after its inception when the Inch Cape Committee set up by the government to overhaul the government finances, recommended that, on grounds of economy, the scheme for Delhi University be dropped. It was the stand taken by the Vice-Chancellor who supported it with facts and figures with respect to student enrolment etc., that saved the University.

In 1938, Sir Maurice Gwyer, the first Chief Justice of the Federal Court was appointed the Vice-Chancellor. With his appointment, a new phase began in the history of the University of Delhi. The university had made no progress in direct teaching except in Law and undergraduate science courses. In August 1939, Sir Gwyer submitted to the government of India, a memorandum for an All India University for Delhi. He conceived of Delhi University as a miniature Oxbridge type of institution, with a cluster of small residential colleges on the campus around the core of the university. A number of professional chairs and readerships had to be established, scholarship and other facilities for postgraduate study and research had to be provided

for. He suggested a three year degree course and better library and sports facilities. All these required increased expenditure. The government of India accepted the VC's proposals and sanctioned a grant of Rs. 2 lakhs, half the amount was to assist the colleges to move to the university site. It was he who introduced the three year Honours degree course to enable the students to specialise in one subject and thus prepare them for postgraduate work. This concept has been accepted by a large number of universities in India. Sir Maurice searched for talent all over the country and among the distinguished members whom he brought to Delhi were : V.K.R.V. Rao, R.U. Singh, T.R. Seshadri, P. Maheshwari and a number of others.

Besides, Sir Mawrice was also very keen on improving the status of teachers and took various measures to improve their salary scales, provide them with staff quarters and give them security of tenure. Delhi University teachers had salaries higher than anywhere else in India. Hence, Delhi was able to attract teachers of good quality. Another important feature was that teachers appointed in the constituent colleges were deemed as university teachers for the purpose of service conditions, pay scales and various other privileges enjoyed by teachers directly appointed by the University.

Fortunately for Delhi University, it found in Maurice Gwyer a man with a vision and the ability to carry his schemes through. He also had a long tenure of 12 years as Vice-Chancellor which

enabled him to translate many of his ideas into reality.

Following the partition in 1947, there was large scale migration to Delhi that changed the character of the city. The population of Delhi more than doubled between 1947 and 1961. This was bound to have repercussions on the educational facilities in Delhi. Displaced students sought admission into educational institutions but there was no room for them. The university, therefore, was obliged to adopt some new regulations and relax some of the existing ones.

The principal administrative authorities of the university were the Court, the Executive Council and the Academic Council. The Governor-General of India was the Chancellor prior to Independence. After Independence as in the case of other Central Universities, the President of India was named the Visitor and the Chancellor generally elected. The Vice-Chancellor is appointed for a period of five years and cannot be reappointed. He is the administrative and academic head of the university and functions through the Syndicate of the Executive Council.

As for the university departments, a number of subjects were introduced in the year 1922. It included Physics, Chemistry, Sanskrit, Arabic and Persian, Economics and History. But after 1947, university departments began to grow both in size and numbers. Apart from these, Delhi University was the first in the country to start correspondence courses in the year 1962. Dr. C.D. Deshmukh was the Vice-Chancellor at that time and he

realised that the university needs some relief if the number of students increased at the rate of over 12% per year. The university obtained a million dollar grant from the Ford Foundation which enabled it to improve library and laboratory facilities.

Both maintenance and development income for the university is provided by the UGC. However, several of its departments receive special grants as they have been identified under its Centres of Advanced Study programme (six of them including physics), Special Assistance programme etc.. Many of these departments have found significant places in the international map of science (University of Delhi 1982: 1-15).

3.8.1 Department of Physics

Establishment :

A postgraduate course in physics was first instituted by the University of Delhi in 1942. This was an important landmark in the history of the department as from then onwards physics teaching in the university has expanded to meet ever mounting demands in the country for the study of this branch of science. The idea of opening a school of theoretical physics and astrophysics was mooted during the time of Sir Maurice Gwyer's Vice-Chancellorship, Professor D.S. Kothari was invited to head the new department. Dr. Kothari had completed his M.Sc. degree from Allahabad University and was a student of M.N. Saha. It was felt that the Indian contribution in theoretical physics had

acquired an international standing, but because of the dispersed nature of the small number of physicists in various institutions, they were unable to make an impact in international science. Further, due to lack of team work, Indian output of research in theoretical physics seemed smaller than what it could have been for a large country and available talent, both actual and potential.

The department was fortunate to have had such distinguished physicists as Prof. D.S. Kothari, Professor R.C. Majumdar and Professor F.C. Auluck, some of whom continued to be associated with the department as Emeritus Professors even after retirement. The high tradition set by these well known theoreticians is being continued by its faculty of which Professor L.S. Kothari, Professor A.N. Mitra and Professor S.N. Biswas deserve special mention.

Teaching :

The department has a full-fledged two year M.Sc. programme besides its doctoral programme. The department admits about 200 students for the M.Sc. programme every year. Some innovations in teaching programmes have been made. The syllabus is regularly reviewed and courses are designed that relate to the research activities of the department. Several specialised theoretical and experimentally oriented postgraduate courses in Solid State Physics, Plasma and Astrophysics, Particle physics, High Energy ysics etc., have been introduced.

Recently a diploma course for physics teachers of local higher secondary schools has been started. This is of two years duration and classes are conducted during vacations and week-ends. It aims to meet the shortage of physics teachers with postgraduate training. It would benefit graduate teachers working in schools and enable them to acquire postgraduate training essential for teaching higher secondary classes.

Research

In 1962, the UGC identified the department of Physics and Astrophysics as a CAS. This was largely in recognition of not only its past achievements but also of its potential for continued research in theoretical physics. However, in February 1966, the UGC decided to rename the centre as the CAS in physics. This revision has resulted in the enlargement of the scope of activities to include experimental physics which it has done to a significant extent. The first landmark was the development of the low temperature facilities with the assistance from UNESCO. Experimental research in areas of Electronics, Semi-Conductors, Solid State physics, Physics of Thin Films, High-Energy physics, Nuclear physics etc., have not only expanded in scope but have also been continuously oriented to modern research trends. Most of the faculty members engaged in research receive large funds from agencies like DST, UGC, CSIR etc. for their work.

Other Activities

The department organises summer schools regularly. In order to help in raising the standards of research and teaching in the universities, the department has provisions for 'floating staff' who could spend short duration in the department (Department of Physics, Delhi University, 1972). The centre regularly invites eminent scientists to deliver lectures and seminars. Located in the capital it has access to personalities of international repute who while visiting India definitely pass through the capital.

To conclude, the following points emerge from the above discussion on the historical details of the selected universities and departments:

1. The background of the initial leader selected to head the new department is crucial to the growth of the department.
2. The flexibility or/and rigidity of the institutional structure affects the functioning of the departments. More specifically, the role of the Vice-Chancellor and the relation between the head of departments and the Vice-Chancellor in a university significantly affects the development of the departments.
3. The impact of the socio-cultural and political developments within the larger society, affects the policy and functioning of universities.

4. The institutional goals and the personality of initial leaders can determine the extent of integration of teaching and research in the departments.

With these observations, we proceed to the analysis of the primary data which will be presented in the following four chapters.

CHAPTER IV

UNIVERSITY DEPARTMENTS: ORGANISATIONAL FEATURES

A structure has meaning within the context of the organisational goals alone and the goals here refer primarily to the two academic duties of teaching and research. In this chapter we will discuss three organisational features of the departments. They are (1) nature of teaching obligations (2) nature of infrastructural facilities available and (3) nature of headship. These will be discussed from the point of view of the respondents towards these features. In addition, the educational background and career profile of the respondents will also be analysed, which might contribute to the understanding of the functioning of departments within the framework of the institutional goals.

4.1 NATURE OF TEACHING LOAD

The sharp differences in the teaching load between the seven departments as shown in Table 4.1 reflects the nature and requirements of the different departments. Bangalore has the minimum as it has only doctoral students for whom a small number of courses are offered. In sharp contrast, we have Baroda X that caters to students from I year B.Sc. upto the doctorate level. The faculty members thus have heavy teaching load at all grades.

TABLE 4.1

TEACHING LOAD : AVERAGE NUMBER OF HOURS PER WEEK

UNIVERSITIES		PROFESSORS	READERS	LECTURERS	RES. ASSOCIATES
BARODA	(X)	10	24	30	-
	(Y)	6	17.5	12	-
MADRAS	(A)	2.5	2.5	6.5	-
	(B)	5	6	5.5	4
	(C)	10	10	7	3
BANGALORE		2	3	-	-
DELHI		11	9	21	-

Baroda Y located in the Faculty of Technology offers some core courses for the undergraduate engineering students. Besides, it has a two year M.Sc. physics programme and a few research students. Their teaching load therefore is not as heavy as that of Baroda X. However, it may be noticed that readers in this department have a fairly higher teaching load than lecturers. It was found that many of them were recently promoted to their present position and while it did improve their academic status, it did not bring relief to them in terms of their teaching load. This was largely because of the fact that there was only one lecturer in the department who was a lady. It was not possible to transfer all the excess load to her, and as a result, we find that readers in this department have higher teaching load than lecturers since they continue to take the load that was assigned to them earlier when they were lecturers.

While each of the three departments of Madras and that of Delhi have M.Sc., M.Phil and doctoral programmes, the members of the faculty do not have similar teaching duties in the four departments. This may be due to number of students, number of courses offered and number of faculty. While the number of students in the M.Sc. programmes of Madras University is around 15 in each batch and the number of research students probably even less, the number of M.Sc. students admitted for every batch in Delhi is around 150 and the number of research students equally high. In contrast to the three Madras departments which

have been set up for different specialisations within physics, Delhi has a faculty with diffused research specialisations. It also has a much bigger faculty strength compared to the three departments of Madras put together. They are thus in a position to offer a larger number of specialised courses for the Masters degree programme. The higher teaching load for respondents of Madras C in comparison to Madras A and B can be attributed to the greater number of laboratory classes that members of Madras C have to undertake.

The above account gives some idea of the nature of teaching obligations respondents in different departments have to fulfill and the time available to them for research and other activities. As is clearly evident Baroda X has maximum teaching obligations and hence very little time for research but Bangalore spends very little time on teaching duties and directs almost all its time towards research which is the major focus of the department.

Reactions of Baroda X respondents towards teaching is one of resentment, as they feel that due concern is not given when it takes away most of their time. Some of them were antagonistic when the investigator approached them with a questionnaire requiring details about their research activity. They feel that the structure has in-built limitations to accommodate research activity, but evaluation for promotions are generally on the basis of their research output. They do not find time at a stretch to do concentrated research due to heavy load of

undergraduate teaching. Besides, as the courses are elementary in nature and have the same syllabus year after year, teaching these courses has become a routine phenomenon and interests them no more. Some courses at the MSc level, they feel, could be useful for their research, but they expressed dissatisfaction as the courses they are given to teach certainly do not relate to research areas that is of interest to them. On the whole we find that very few scientists in Baroda X are engaged in research and such scientists opined that they had always found time to do their research work.

In sharp contrast, we have the Bangalore respondents who have very little teaching duties. The courses they teach have a direct bearing on the research specialisation of the faculty members and they have complete freedom to restructure these courses from time to time. They do not consider teaching as a hindrance to research for it is an essential requirement in their process of training research students for the doctorate degree. In addition, some respondents felt that teaching disciplines their activities as it forces them to update their knowledge regularly and also enables them to be punctual in reaching the workplace.

As for the remaining departments, we find that Baroda Y respondents feel very much the same way as their colleagues of Baroda X. Their main teaching duties involve core courses for the engineering students, which takes away a lot of time in

preparation, correction etc., as the classes are generally large. The MSc programme on the contrary does help to make their ideas clear, but does not allow sufficient scope to relate it to their areas of research interest. Further, in the respondents' view, when motivated students do not join the MSc programme the classes become uninteresting and monotonous.

This is sharply in contrast with the opinion of the Delhi respondents who consider the standard of their MSc courses commendable and also speak highly of their students. While respondents from both the departments -- Madras A and Delhi do not consider teaching as a hindrance to their research, we still find a difference - Delhi physicists look forward to teaching but those from Madras A are in a way indifferent to it. This is largely due to the fact that the MSc and Ph.D. programmes in Madras A are confined to one area in physics -- Crystallography and Biophysics, but Delhi as mentioned earlier has faculty with varied interests. As such they look forward to offering special papers based on their research specialisation, for in this way students are exposed to different areas and may be motivated to register for research. With research students, their individual research activity is ensured.

For the physicists of Madras B, teaching is helpful as it helps them to organise their reading and to present ideas logically. This is considered as an essential exercise for it helps in conducting research and presenting research results to

different kinds of audience. Though Madras C respondents realise that teaching helps them to understand better what they already know, they feel they are overburdened with classes, mainly laboratory classes. They basically look forward to the expansion of the department, whereby teaching load will be shared and time to concentrate on individual research will be available.

4.2 AVAILABILITY OF INFRASTRUCTURAL FACILITIES

We have broadly classified the infrastructural facilities under three categories: libraries, laboratories and funds. Library facilities have been further classified into availability of books and journals separately. Details in Table 4.2 give an idea about the availability of these facilities from the point of view of the interviewees.

4.2.1 Access to Books

Data analysis shows that 69% of the respondents are content with their library facilities with respect to their need for books. Satisfaction level is low for the respondents from A of Madras and Delhi, when compared with the remaining five departments. In contrast satisfaction level is very high for the Baroda respondents and for those in Bangalore and Madras B. It has to be noted here that while the Baroda respondents referred to books required for their teaching purposes only, for the remaining five departments it meant books useful for both teaching and research. Reasons for the low level of satisfaction

TABLE 4.2

NATURE OF INFRASTRUCTURAL FACILITIES

UNIVERSITIES	LIBRARY				LABS(100%)		FUNDS(100%)		TOTAL RESPONDENTS IN EACH DEPTT.
	BOOKS(100%)		JOURNALS(100%)						
	ADEQUATE	IN-ADEQUATE	ADEQUATE	IN-ADEQUATE	GOOD	UNDER EQUIPPED	SUFFICIENT	IN-SUFFICIENT	
BARODA (X)	(86%)	(14%)	(71%)	(29%)	(78%)	(22%)	(36%)	(64%)	14
(Y)	(91%)	(9%)	(58%)	(42%)	(17%)	(83%)	-	(100%)	12
MADRAS (A)	(46%)	(54%)	(46%)	(54%)	(31%)	(61%)	(54%)	(46%)	13
					N.A.-8%				
(B)	(77%)	(23%)	(45%)	(55%)	(33%)	(33%)	(33%)	(67%)	9
					N.A.-33%				
(C)	(66%)	(34%)	(34%)	(66%)	(17%)	(50%)	(83%)	(17%)	6
					N.A.-33%				
BANGALORE	(77%)	(23%)	(88%)	(12%)	(89%)	-	(100%)	-	9
					N.A.-11%				
DELHI	(54%)	(46%)	(46%)	(54%)	(42%)	(46%)	(50%)	(50%)	24
					N.A.-12%				
TOTAL	(69%)	(31%)	(55%)	(45%)	(45%)	(43%)	(47%)	(53%)	87

N.A. - Not Available

varied from one department to another.

It was learnt that the respondents in Madras A were unhappy because they did not have an organised departmental library. Far away from the main university campus and the central library, physicists of this department find it difficult to keep track of books. Madras university library is one of the oldest in the country, is very large and its membership is open to the general public. As a result books get misplaced and become difficult to trace. The respondents therefore feel that both these factors of distance and the nature of the main library all the more necessitate the provision for a departmental library located within their campus so that books are easily accessible to them. They say that such libraries do exist within the same university, for example - B of Madras have already shifted books related to their needs to the department.

In contrast, Delhi did have a full-fledged departmental library as part of CARPA (Centre for Advanced Research in Physics and Astrophysics), but the respondents were sore about its inefficient management. When the opinion of the library staff was sought in this connection, they complained about the irresponsible attitude of the faculty. Books are seldom returned inspite of repeated reminders. Relations between the academic and non-academic staff are strained and are not very meaningful.

The nature of problems with reference to books as stated by

the respondents may be listed as follows :

(1) Bad organisation and inefficient management of university library causes difficulty in procuring books.

(2) Non removal of old outdated books and replacement with new ones unlike libraries in the west restricts space for expansion. As a result, library collection is generally 10 to 20 years behind the latest material.

(3) Budget for books from the university has not proportionately increased with inflation rates. Added to it, is the 'unhealthy' method of alloting substantial money for books towards the end of the financial year giving very little time to spend the money. This has resulted in hoarding such books as are available in the market at that point of time, as books from abroad take some time to arrive (at least 3 months) when one places an order. This has led to an unwanted collection of books.

(4) Respondents from three departments, of Madras for example are unhappy about the poor functioning of inter-library loan facilities, which may at times help to offset some of the maladies of their own library.

(5) Certain others, like the respondents of Delhi, find the decentralisation and splitting of the library into Arts, Science etc., very inconvenient. Books and journals are separated and located in different places. One can become a member of only that library directly relevant to one's own discipline. This they feel has affected their general exposure and reading habits to a

great extent. According to them, all the above mentioned factors, contribute to the increasing ineffectiveness of the system.

4.2.2 Availability of Research Journals

Details of Table 4.2, show that the satisfaction level is high for the Bangalore and Baroda X respondents with respect to journals. However, the focus and needs of these two departments are different. The Baroda respondents require few research journals for their teaching activities. For the Bangalore respondents, research is the main concern and hence their journal needs refer to specialised research journals related to their area -- Molecular Biophysics.

Turning to the discontented respondents, we find that they belong mainly to the three departments of Madras, Delhi and Baroda Y. The problems related to journals as highlighted by them both specific to the department and of a general nature are as follows:

(1) A common grievance of respondents across all departments is the lack of a proportionate increase in the journal budget with increasing subscription rates. As a result, journals are reduced in number and this fact has significantly affected their exposure to current research material.

(2) Added to the above is the enormous delay in the arrival of journals as they are sent by sea mail. Some respondents are

frustrated by such delays because the anxious author has to wait for a long time to see his own paper in print.

(3) While the problem in the first place refers to procuring journals, the next step concerns their use. A general complaint is that students remove crucial articles causing difficulty to others who have similar interests. This to some extent reflects on the organisation and management of the library. Rules of entry and exit vary from university to university and efficiency is low in big public libraries like the Madras University library.

(4) A very major problem concerning journals is the absence of a systematic method for procuring back volumes of journals, which the respondents feel are extremely essential, but which are neglected by almost every university library.

(5) The scientists in the theoretical physics department of Madras B feel that they are able to carry on with their research as they have an effective pre-print exchange system, not because they have access to specialised research journals.

The respondents however do not stop with airing grievances. They have also made some feasible sugggestions. The nature of present day science is towards increasing specialisation, generating more and more specialised journals. Added to it is the increase in subscription rates of existing journals. At times a number of research and teaching institutions are found

located in the same city. Invariably they all have libraries and regular budgets are allotted for procuring journals. But one finds little co-ordination among these libraries. Some journals are repeated in all libraries while some journals are available in none. The respondents have suggested the setting up of a 'Central library facility' in such places where money could be pooled and a larger number of journals procured. Besides, when journals are repeated, the respondents feel that substantial foreign exchange is wasted. What happens in reality according to them is that, the librarian in order to maintain the number with budget cuts, ends up subscribing to substandard journals. They feel that stock taking is rarely done and journals are seldom a topic for discussion. In addition; grants from the UGC to update old libraries are hardly available. One respondent from Baroda Y was very unhappy, when the question of journal was raised and retorted, "Journals? we get only magazines".

4.2.3 Experimentalists and Laboratories

As data analysis shows in Table 4.2, laboratories are relevant to respondents in almost all departments with the exception of Madras B. Teaching laboratories, if not research laboratories, are found in all departments. However, the satisfaction level is high only for respondents of Baroda and Bangalore. The Baroda respondents mainly refer to under graduate teaching laboratories that cater upto the M.Sc level which they regard as good but consider the research laboratories

as poor, insufficient and requiring modernisation.

In contrast, the Bangalore respondents refer to research laboratories and feel that they are adequate, well-equipped and probably the best available in India for doing research in Molecular Biophysics. Though these laboratories may be a couple of years behind international standards they are sufficient enough if one wants to work efficiently. Respondents from the remaining departments of the study have some problem or the other with their laboratories. The nature of problems as expressed by them are as follows:

Some universities/departments have been established without a long term perspective for expansion. Hence some departments for example Delhi, do not have space for expansion. Instruments are congested in small rooms which restricts further acquisition of instruments and hence research activity, is limited. A major problem relates to funds available for the maintenance of laboratories. This refers to both teaching and research laboratories. According to them while funds are available to buy instruments, regular money and expertise for their maintenance is lacking which is a major drawback. This, significantly affects the continuity in their research work. This seems to be a major problem in Delhi and Madras C.

Besides these general ones, some specific problems related to departments, have also been expressed. Respondents from Madras A opined that while research laboratories for the main

area of specialisation, especially of interest to the head, are generally well-equipped, the faculty members interested in other areas at times have to seek the help of other departments or institutions in order to do their research work. Some Delhi respondents viewed the problem differently. As there were no fresh recruits to the department for more than ten years, there was a dearth of enthusiastic youngsters to improve laboratories. Seniors were too busy and had no time for such small things. The net result is that laboratories are old fashioned and experiments are seldom in working condition.

4.2.4 Support of Technical Staff

One important aspect has to be considered here -- the role of the supporting staff in laboratories. When the opinion of the respondents was sought in this connection, only the Bangalore respondents were happy about the support of the technical staff. They were considered good and efficient. The respondents claimed that the screening and selection procedure for such staff is so careful and efficient that there is no question of hiring sub-standard staff. On the other hand, the respondents from all the other six departments were singularly unhappy about the performance of the technical staff. In Madras A and C the complaint was that the technical staff never work willingly or enthusiastically.

The Delhi respondents on the other hand were rather bitter about their experience. The problem here is that there are more technical staff than required, but none of them is in the first place competent enough to operate or repair instruments. Such a situation has arisen largely due, in the respondents' view, to the university policy. On the demands of the karamchari union (workers union) the university promoted even chaprasis (peons) to the post of laboratory assistants. Such staff are untrained and they refuse to learn even when they are promoted. A general attitude to shirk work prevails among them. If the head or any other faculty member is assertive and demanding, the technical assistants request for a transfer and most often leave the department. One respondent went to the extent of saying that the office staff and technical staff instead of being two supporting legs are in fact two thorns. However, some responsibility lies with the faculty member too, the respondents admitted. Technical staff are generally used as peons, to make tea and for other menial purposes instead of being trained to operate instruments.

Nevertheless, there were a couple of respondents who spoke in support of the technical staff. A physicist from Madras C felt that these staff are more important than the clerical staff but their contribution is very little recognised in India. This is in sharp contrast to the status of technicians in the west where they are co-authors in many important papers. When one technical assistant in Delhi became very excited with the arrival

of personal computers, a faculty member tried to explain and teach him how to work with computers. It was learnt that the head of the department warned the faculty member, that it was a waste of time to teach the laboratory assistant for a student could be trained instead. As one Delhi respondent expressed, the technical staff see students whom they have helped return as faculty but their status hardly improves. This has resulted in fewer committed and skilled individuals applying for such positions.

It is interesting at this juncture to relate a conversation between two laboratory technicians that was overheard in a university canteen. Their grouse seemed to be that they were also fairly good students at the B.Sc. and M.Sc. levels but had to take up such jobs due to certain personal constraints. Being constantly in the laboratories, many technicians develop some interest in research problems and dabble with experiments. In fact, they feel that they are much better than some Ph.D. students, too. On the contrary, their status is much lower and they are not allowed to register for a Ph.D., if they so desire. The two men referred to earlier, were youngsters and probably wanted to improve their qualifications. Technicians thus seemed a category apart in almost all departments except for Bangalore. Here they seemed well integrated with the researchers and there are instances where some of them have switched over to become full time research students after serving a couple of years as

laboratory assistants.

4.2.5 Funds: The Indispensable Factor

Money is a crucial factor in any discussion of infrastructural facilities. Whether it is the question of books, laboratories, trips to attend conferences or to get material xeroxed, the availability of and accessibility to funds is a significant factor. The sources of funds to universities vary according to their nature of establishment There are however two levels in which money is disbursed within a university. (i) directly to the library and other institutional facilities available to all (ii) funds to different departments for maintenance, improvement of laboratories etc., over which budget the department has certain autonomy. It is primarily with the latter aspect that we are concerned here.

But before going on to discuss the details of Table 4.2 with reference to funds and the attendant problems faced by the respondents, it may be worthwhile to have an idea about the source of main funding in the four universities.

M.S. University of Baroda is primarily dependent on funds made available to it by the state government. Income generated from fees etc., is very meagre and cannot support any new educational programme. Its income from the Maharaja's Trust with the help of which the university was initially established continues but is not sufficient enough to meet the requirements

and hence it largely depends on the state government.

Madras University in its initial years was drawing grants from the government of India and was not able to receive support from private benefactors. After independence, with provincial autonomy, the university came under the control of the state government which now provides block grants to the university for both maintenance and expansion.

Besides the income from the Tata Trust with which the Indian Institute of Science at Bangalore was born, the UGC supports it substantially both in the form of Plan and Non-Plan grants. Delhi being a Central University obtains both its maintenance and development income from the UGC.

The Department of Science and Technology is one of the major funding agencies of the government and has the responsibility of formulating policy statements and guidelines on science and technology. It used to distribute funds under two schemes - The General Research Scheme (GRS) and the Science and Engineering Research Council (SERC). Project proposals submitted are refereed following which funds for research are disbursed to individual scientists or groups of them. Funds are available under five main disciplines: Chemical Sciences, Engineering Sciences, Life Sciences, Physical Sciences and Earth and Atmospheric Sciences. However, in each of them, 'thrust areas' or frontier areas are identified and research work in them are supported. A scientist or scientists working in any kind of

TABLE 4.3

NUMBER OF PROJECTS SANCTIONED TO VARIOUS CATEGORIES DURING 80-85

AREA	UNIVERSITY		COLLEGES		IITs		IISc.		AIIMS		RES. INSTS.		TOTAL
	G	S	G	S	G	S	G	S	G	S	G	S	
Chem. Sc.	30	15	5	-	16	8	7	9	-	-	12	4	106
Life Science	99	49	37	2	-	8	8	9	14	7	37	19	289
Physical Sc.	47	38	11	2	18	22	5	10	-	-	15	13	181
Engg.Science	6	5	6	4	14	16	7	4	-	-	3	5	70
Total	182	107	59	8	48	54	27	32	14	7	67	41	646

G - GRS or General Research Scheme

S - SERC or Science and Engineering Research Council

Source : SERC Activities during 80-87, DST, New Delhi
Table III, Appendix, p. 76.

educational, research institution are eligible to benefit from these funds. Table 4.3 provides some idea on the distribution of such funds institution-wise.

The figures in Table 4.3 give a very impressive picture with regard to the number of projects sanctioned to universities. At the same time, one should take note of the fact that the two institutions Indian Institute of Science Bangalore and All India Institute of Medical Sciences, Delhi are treated as separate categories. When the average cost of an approved project to different kinds of institutions is compared, the following details emerge.

Data analysis in Table 4.4 shows that a university project has lowest average cost under the GRS scheme and is the second lowest under SERC. It should also be mentioned that the highest average cost of a project is generally among the premier institutions of the country, that have several other agencies like the Department of Atomic Energy, Electronics, Space etc., apart from the relevent Ministry to support them.

The Council of Scientific and Industrial Research (CSIR) is another body to which scientists can aply for research funds. Apart from supporting the research institutions that are established directly under its purview, the CSIR also provides funds under its 'Extramural Research Schemes' to individual scientists for short periods of time.

With this account on the applicability, availability and

TABLE 4.4

AVERAGE COST OF AN APPROVED PROJECT - INSTITUTION WISE
(RUPEES IN LAKHS)

INSTITUTIONS	GENERAL RES. SCHEME	SCIENCE * ENGG. RESEARCH COUNCIL
UNIVERSITIES	4.64	6.86
COLLEGES	6.26	6.89
I.I.Ts.	5.54	5.7
A.I.I.M.S.	9.48	10.29
I.I.Sc.	8.35	11.23
AUTONOMOUS RES. INSTN.	6.88	7.36

SOURCE: SERC Activities during 80-87, DST, New Delhi, p. 79

accessibility of funds to scientists working in universities, we now turn to its relevance for our respondents.

4.2.6 Availability of Funds and Respondents' Research

Referring to details in Table 4.2 the satisfaction level of respondents is moderate to high with reference to its sufficiency of funds for research. While the Bangalore respondents are contented unanimously, all the respondents of Baroda Y are totally distressed about its inadequacy. Resources from the university almost always appear to be meagre in relation to the demands that are to be met. This money they feel is insufficient even to maintain teaching laboratories or to take care of other normal expenses; the question of planning major expansion based on this resource does not arise at all. They have to approach agencies like the UGC, DST or CSIR for such funds either independently or through joint representations. However, there was general agreement among them that large money was certainly available for research and a motivated researcher would be able to obtain funds from some source or the other. It may involve a little running around, but as this is a general feature of any bureaucracy in the country it cannot be treated as a special complaint, they added. The sources from which our respondents have drawn research funds is given in Table 4.5.

There are some specific problems involving funds which the respondents face. One kind of apprehension they hold is that a researcher has to be a senior faculty and/or well connected in

TABLE 4.5

SOURCE OF RESEARCH FUNDS AVAILED BY RESPONDENTS

UNIVERSITIES	SOURCES
BARODA (X)	M.S. University, State Government, DST, Gujarat Industrial Council, UGC and CSIR
BARODA (Y)	DST, UGC, CSIR, BARC, DAE
MADRAS (A)	UGC, CSIR AND DST
MADRAS (B)	Madras University, DST
MADRAS (C)	DST, CSIR, UGC; DAE, DRDO
BANGALORE	DST, UGC, CSIR, DAE, INSA AND ICMR
DELHI	UGC, DST, DOE, DOS, CSIR, National Bureau of Standards, INSA, Ministry of Defence, NSF (USA), ICMR and ISRO.

order to obtain funds. Seniority and experience they feel has greater weightage. However, it was noticed that where researchers function as groups, the problem of funds does not arise. Seniority hardly matters and in fact senior faculty take active interest in encouraging juniors to submit proposals on their own. This has been the case with Madras A in its earlier days and seems to be the situation in Bangalore at present. Where hierarchy and distance amongst faculty are prevalent individual effort is required and hence the problem of acquiring large funds. Modern science, especially experimental work requires both sophisticated instruments and man power. Group formation therefore for fulfilling research goals has become indispensable.

Another dimension to the funds problem relates to the role of the institution i.e. universities where they are working. Respondents unanimously opined that money once sanctioned by an external agency has to pass through several sections of the university bureaucracy before it finally reaches them. This entails unnecessary delay in the progress of research activity as it affects the purchase of instruments and other necessities besides dampening the spirit and enthusiasm with which the project had been envisaged. Sometimes, by the time the formalities are through, the research problem itself may get outdated. Further, the respondents were aggrieved about administrative staff taking decisions about sanctioning money for

technical purchases.

Scientists have made representations for direct channelling and granting autonomy to them with respect to the funds allotted. This, they feel would help in minimising the misuse of funds. When the Madras scientists enquired about the delay within the University once the money was sanctioned by DST, they were requested to wait for sometime as the funds were being used to pay the salaries of the employees and overcome some financial crisis that the university was facing. In view of these problems, the UGC has made attempts of late to take care of such delays and enable direct granting of funds to the scientists.

Some respondents are also of the opinion that when money is sanctioned in instalments by the university which is mostly the case, large scale planning becomes difficult. Small sums invariably are spent in a number of ways. This they feel is detrimental to continuity in research and in a way accounts for the slow pace of research in university science departments.

Apart from these, there are specific department related problems that bother our respondents. The physicists from Baroda Y apart from expressing the absolute inadequacy of funds, are also unhappy about the step-motherly treatment meted out to them, as members of Faculty of Technology. They feel that only that money, which is not utilised by the other engineering departments of the Faculty of Technology is diverted to them and

research in their department is never given any priority.

Some suggestions have also been made by our respondents to alleviate such lapses. One suggestion refers to persuading the university to regularise payment of ad hoc grants that may be adjusted when the money from outside agencies is actually realised. This they feel will help to minimise discontinuities in research programmes and cause less tension to the scientists. Besides, it may also bring credit to the university through its research productivity.

To sum up this section on the availability of infrastructural facilities, we find the Bangalore and Baroda respondents are highly satisfied with their library facilities in terms of access to books and journals. While the Bangalore respondents' satisfaction is in terms of their research requirements, for the Baroda physicists satisfaction is with reference to their teaching requirements. The remaining five departments differ only in degrees of discontentment. For Madras A physicists it is a problem of distance from the main library and difficulty in tracing books as the library is open to the general public. Availability of books and journals are not problems for Delhi physicists, it is the decentralisation of the library and inefficient management that causes difficulties and delays.

The pattern is very much similar when one considers laboratory facilities. Both Bangalore and Baroda X are highly

satisfied in their own way. Whether in terms of availability of space for expansion, procurement and maintenance of instruments or support from the technical staff, the Bangalore respondents have no problem. The Baroda physicists refer to teaching laboratories for the B.Sc. and M.Sc. students which they find adequate enough. The remaining five departments feel that their laboratories are significantly under-equipped and ill-maintained. While the Delhi respondents complain about lack of technical staff support, the physicists of Madras A and C feel that it is primarily a problem of scarcity of funds to improve research laboratories that hinders progress in research.

With respect to funds, while all the Bangalore respondents are thoroughly satisfied with the availability of funds for research, the Baroda respondents especially Baroda Y are totally dissatisfied in this matter. While both these departments seek the help of funding agencies for support, there is a wide difference in the nature of financial assistance. Assistance to research projects in Baroda are always minor - a few thousands of rupees, but grants to Bangalore are always major - runs to several lakhs of rupees. For the remaining departments, funds from UGC and other agencies are possible, but specific problems related to departments like the diffused research interests of Delhi physicists or disharmony among physicists of Madras A pose problems in the actual acquisition and use of funds. Besides, there are institution related problems like the role of

university bureaucracy that affects the timely disbursement of research funds.

The availability of these infrastructural facilities can to some extent be related to the status of the seven departments. Bangalore and Delhi figure under the Centres of Advanced Study Programme of the UGC which entitles them for regular large scale assistance for research. Madras A also receives some support from the UGC under its Special Assistance Programme. Madras B and C obtain funds under the COSIST programme of the UGC. These schemes take care of the laboratory and related needs of the respondents to some extent. In contrast to all of them Baroda X and Y depend largely on university finance, for their departments do not figure under any scheme of the UGC. M.S. University Baroda is a Unitary State University and depends entirely on the policies of the state Government for any increase in funds.

4.3 HEADSHIP AND ORGANISATION OF DEPARTMENTS

The organisational culture that is built within the department is more significant for the success than the infrastructural facilities available. Two essential coordinates of the organisational culture of university science departments can be identified (a) Directedness and (b) Democracy. The structural features when studied in terms of these coordinates provide interesting insights.

The formal institution, by itself is probably little useful

in understanding the oranisational culture. But, when one attempts to relate the system with the personalities who occupied or occupy positions of power, leadership, directedness and the eventual success or failure of departments can be better understood.

University departments in India traditionally followed the system of a single professor and permanent headship. This was in line with the German university model that characterised a "community divided by gaps of authority and power rather than one by competence". (Ben David, 1971: 122). Though a professor was selected from the community of scholars on the basis of his competence, his academic competence and organisational capacity need not always go together. But an efficient leader with academic proficiency could build a department and guide its growth towards achieving well defined goals.

In our study of seven university physics departments we find that in two of them - Madras A and Delhi, the selection of young and dynamic persons to head the newly established departments resulted in the success of the departments. It was Professor G.N. Ramachandran in the case of Madras A and Professor D.S. Kothari with respect to Delhi. The former built Madras A into a centre for advanced research in Crystallography and Biophysics and the latter launched the physics department of Delhi as a key centre for advanced research in Theoretical physics mainly Astrophysics. However, leaders working within the system of permanent headship do face the danger of becoming dominating and

autocratic.

In contrast, the first head of a department can also turn out to be a 'bad leader' under the system of permanent headship. As a result the department may be directed towards taking care of vested interests of the head and thereby suppress the initiative of the rest of the members of the department. A bad leader can also mean an inefficient and indifferent one, who will be unable to give any direction to the department. This seems to have been the problem with Baroda X in our study. The choice of the first head seems to have been a significant factor that accounts for its present status. Recruitment of faculty members seems to have been primarily geared towards fulfilling the minimal obligations, i.e. teaching.

It was primarily to take care of the 'problems' generated by the selection of 'bad leaders' under permanent headship, that the UGC introduced the American model of rotation of headship. Not only was power to be circulated, but was also decentralised. A number of committees consisting of the faculty members of the departments were to be set up to take care of different aspects of the department's functioning and the head was to function only through such committees. These committees were not only to aid the head but was also to make the system more democratic.

In our study of seven departments, the three departments of Madras followed the system of permanent headship and the

remaining four followed the system of rotation. They are: Baroda X, Baroda Y, Bangalore and Delhi.

However, there seemed to be differences among these four departments in their style of functioning. The heads hold office for only a period of three years in all the departments, but the process of selection varies. While in Bangalore selection of the head, though limited to professors, is not entirely based on seniority, this seems to be the main criterion followed in Baroda. Thus in Baroda X, one finds professors taking up headship even at the fag end of their careers. Such a practice is not prevalent in Bangalore. Councils and committees are prevalent in both the departments, and the head functions through them. However, in Bangalore, it was noted that the Chairman (that is how the head is known) functions merely as the secretary of the department, for all decisions are made by the several committees constituted to take care of different aspects of the department's functioning of which he is also a member. Besides, all senior professors are consulted in all policy matters. Since the department functions as a group with common 'research goals' respondents opined that the position of the head hardly carries any extra influence. In the words of a respondent "one is made a chairman not only by consent, but remains in that position and continues to do so at times for more than one term, because his colleagues want him to, not because it is the Director's choice".

In contrast, the system of rotation was not very effective

in Baroda X as the department had little overall perspective towards research. The main goal was to take care of the teaching needs. This is largely due to the diffused nature of interests of the members. Democratic way of functioning is certainly adhered to as the head functions through committees. But, the varied interests of members only led to issues getting diffused in committees leading to very little progress in terms of departmental activities. The problem the members say is further aggravated when indifferent or inefficient individuals occupy the position. The system of rotation of headship has some in-built contradictions. With continuous change of heads there is bound to be some discontinuity in follow up of issues. If the department is further characterised by factions, then chances of undoing whatever an earlier head had tried to introduce, seems likely by a succeeding head. The system cannot be universally effective as it varies with situation. In the case of Baroda X, the respondents feel that it has only given rise to competition for power and undesirable politics. It was learnt that this department even went without a head for several months, due to some differences between the university administration and the department. The acting head during that period evaded issues and never took any firm decision when situations demanded. Such an experience has made some respondents prefer the older system of permanent headship as it contains fewer uncertainties. Some general advantages and disadvantages of the system of rotation as

perceived by the respondents are given in Table 4.6.

Delhi department occupies a place much closer to that of Baroda in this respect. Headship is rotated amongst professors based on their seniority. If a professor refuses to accept the position, it then passes on to the next one in line. Members expressed that rotation of headship is essential as it removes monopolies and destroys concentration of power in a few individuals. The department does function primarily through its committees. However, due to its large size (fifty two members) and diffused interests, respondents opined that it is very difficult to arrive at a consensus on any issue. In spite of this, they would still prefer rotation to permanent headship as permanent heads tended to become autocratic. They are of the opinion that their committees function very effectively. Disagreements between the head and the committees has even lead to the resignation of a couple of former heads. However, the respondents show great concern for the effective functioning of both the committees and the head. Failure of either by having indifferent or inefficient heads may give rise to a situation where they fear the non-academic staff of the university may gain an upper hand in university affairs. This they feel is not healthy for an academic institution as it then faces the danger of being reduced to a mere bureaucratic organisation.

Some suggestions have also been made by the respondents to

TABLE 4.6

ROTATION OF HEADSHIP

ADVANTAGES	DISADVANTAGES
1. Diffusion of power in Committees. No decision taken solely by the Head	1. One who wants Headship merely wants power. Department therefore suffers
2. Many are eligible and can aspire which can motivate them to function effectively	2. It can also bring indifferent or inefficient persons as Heads
3. Holds office for a short while. Limited harm done to departments	3. At times, the efforts of an earlier Head are undone by a later one
4. Seniors too get time to do their research work	4. Competition for Headship leads to ugly politics and degeneration
5. The attitude of non-academic staff towards faculty changes	5. Non-academic staff gain power. It often becomes a problem for the department
6. Helps especially when there are many differences among faculty	6. Students of senior faculty becoming Heads act as mere figure Heads
7. Criticism becomes effective as everyone has a chance to experience Headship	7. Too much democracy can affect progress
8. Reduces harassment of individuals	8. There can be no continuity in policy matters
9. Head is merely a convener, a link between the department and the university administration	9. Rotation good only when there are equally competent faculty members

take care of some of the problems of this system. One respondent narrated his experience in Australia. One of the criteria adopted to select a head in that university was that he should have at least 10 years of service left. Such members, it is felt, would continue to retain some interest at least in the department's progress. This would eliminate chances of disinterested professors at the fag end of their careers occupying positions of importance - headship in this context. This criterion, our Delhi respondent feels, could as well be applied in India which would result not only in having younger and more energetic heads but also provide for greater continuity in policy matters.

With respect to Baroda Y, the pattern is not very clear. They followed permanent headship from inception (1969), till the mid 70's. The department then effectively had only one professor who was the head. He had built a team of researchers including younger colleagues and in a way dominated the department. The members opined that no other choice was available within the older system. At the time of the study the department had a couple of young professors and one of them had taken overas the head because the system of rotation had been introduced and the senior professor had retired. The respondents felt that it was too early to comment either on the new head or on the system of rotation though they viewed it in a positive manner.

The three departments of Madras follow the system of

permanent headship. It was learnt that during the Vice-Chancellorship of Malcolm Adiseshiah (75-78), rotation of heads was introduced. It is understood that the next Vice-Chancellor G.R. Damodaran reverted to the old system due to pressure from senior professors (who had lost power) and from the university bureaucracy. The latter had complained that communication with some of the new heads was proving to be difficult as they raised too many questions and doubts. The university administrators expressed the view that this factor was adversely affecting the effective functioning of the university as a whole.

Permanent headship thus came to be re-introduced in Madras University. However, in the three departments of our study, we found that democracy did exist to some extent. Committees were functional. In fact, some respondents of Madras A were of the opinion that the head was in fact too liberal, while what is necessary is some amount of firmness. In Madras B, a faculty meeting is said to be held once every month where all departmental activities are discussed. Opinion of members in Madras C is sought informally by the head regularly on all important policy issues. In a way, members of all the three departments did not seem to have any serious problem with the system of permanent headship. They however clarified that this feature may be the case with their departments which are relatively smaller in size. Informal interaction has been possible, and is meaningful. But they apprehend that the

situation may not be the same when the department grows in size. The situation is not the same in certain other departments even within the same university, as heads in some departments function as patriarchs and are treated as demi-gods.

To summarise this discussion, we find that rotation is more successful in Bangalore as the head works within the framework of a department which has been constituted with well-directed research goals. The head is chosen by consent and he works in co-ordination with the committees. As a result there is greater democratisation, less disharmony and the head functions as a mere secretary of the department. In contrast, the same system of rotation seems less effective in Baroda X. This is largely because of the diffused nature of interests of the recruited members. Besides, headship by rotation has also brought indifferent and inefficient heads as it is mainly based on seniority. The system in Delhi resembles Baroda X in many aspects. Due to its large size and faculty members with diffused interests, priorities conflict. The head as a result has been unable to become either a leader or a secretary of the department ever since the system of rotation has been introduced.

Basically, three types of cultures exist when one looks into the system of headship. They are (i) Autocratic (ii) Democratic and (iii) Chaotic. The system of permanent headship can function at different levels between undirected autocracy and complete democracy. A good leader though being autocratic may be able to

build a successful department. But an autocratic and bad leader may ruin the growth of the department permanently. The system of permanent headship may be more suitable if a department has to be built within a specific time span. In such a situation, a competent person with proven efficiency may be allowed to continue. However, such a system would be successful only if the head has both formal and informal consultations with his colleagues regularly. Some evidence for such a type of functioning is available with respect to the three departments of Madras.

Mulkay and Williams call this kind of headship 'benevolent dictatorship' (1971: 79). They make this observation in their study of a physics department in a Canadian university. It is dictorship because policy decisions were made by the head. It was benevolent because departmental opinion was regularly sought, primarily to see whether the faculty at large were in agreement with the goals of the department and the methods adopted in attaining them.

In contrast, the system of rotation can range from an ideal combination of high democracy and high directedness to an absolutely chaotic, inefficient and degenerate state of affairs. In reality one finds a rare occurrence of the ideal. Bangalore however provides some evidence. One finds greater prevalence of a high rate of democracy almost in all departmental activities with committees playing an effective role. But it has been noted

that when these departments have minimal direction, democracy with diffused interests of members is likely to affect directedness and ultimately retard progress. Baroda X and Delhi show ample evidence in our discussion for stagnation due to such features.

To ensure greater effectiveness of the system of rotation, respondents of Baroda and Delhi have put forth some suggestions. One, that rotation should not be restricted to professors, but should also include senior readers who may be equally capable of handling the job. They propose a system where members work with a spirit of collegiateship rather than within a system of hierarchy. Second, to have some check on the heads they suggest a system of evaluation of an individual's tenure when it is completed. This they feel may induce members to take their positions seriously and not while away their time or misuse the power vested in the office.

In sum, we can say that there is no one system that may be universally applicable to all places and situations. Rotation for example can have no meaning in a large number of university departments in India which are generally very small in size. At times they consist of even 2-3 members. The success of any type therefore depends on the university/institution in which a department may be located, the specific goals and perspectives of the department concerned, the orientation and ambitions of the individual scientists recruited and above all on the personality

of that individual who may be chosen to lead or guide the department with the position of 'headship'.

4.4 EDUCATIONAL BACKGROUND OF RESPONDENTS

We now proceed to discuss some specific aspects of the organisation of departments, especially values pertaining to teaching and research that are established in the seven departments. One way of looking at it is through an analysis of the educational background of respondents. Inferences drawn would provide insights on the criteria followed for recruitment which in turn would reflect on the goals and values of the departments.

The educational background of the respondents is seen from the point of view of their familiarity with the departments/institutions where they have finally found jobs. More specifically, the following will be looked into: whether they have been students of the same department only upto the Masters level; whether they have done their doctorates too in the same department and continued their post-doctoral work etc.. We will then discuss the background of those members who have had their education outside the institution where they are working.

4.4.1 Respondents Trained in Same Institutions Where Working

As shown in Table 4.7 at least 50% of the faculty in these institutions have been students of the same department for some

TABLE 4.7

EDUCATIONAL BACKGROUND OF RESPONDENTS FROM THE SAME UNIVERSITY WHERE WORKING

UNIVERSITIES	M	M+D	M+D+PD	D	D+PD	P.D.	M+P.D.	NUMBER FAMILIAR	TOTAL NUMBER OF RESPONDENTS
BARODA (X)	2	6 (42%)	1	3	0	1	0	13	14
(Y)	4 (33%)	3	1	2	0	0	0	9	12
MADRAS (A)	0	4	0	5 (38%)	0	0	0	7	13
(B)	1	3	1	1	0	1	1	7	9
(C)	0	4	1	1	3 (50%)	0	0	5	6
BANGALORE	0	0	0	0	3 (33%)	1	0	4	9
DELHI	7 (29%)	7 (29%)	0	6 (25%)	0	0	0	19	24
TOTAL	14 (16%)	27 (31%)	3	18 (20%)	6	3	1	72 (83%)	87

M - Masters
D - Doctorate
PD - Post Doctorate

period of time in their educational career. Indian Institute of Science, Bangalore is the only institution that has less than 50% of its faculty who are already known. This may be due to the facts that (a) It has no Masters programme (b) It was only 15 years old and hence most of the senior faculty have been trained outside I.I.Sc.

If one looks at the numerically preponderant category among those who had been students of the same department, we find that those who had both Master's + Doctorate degrees from the same institution constitute 31% of the total sample. There is greater incidence of this pattern among the respondents of Baroda.

Following closely is the category of those who have only their Doctorate degree from the same department. They constitute 20% of the total. The main members of this group are from Madras A (38%) and Delhi (25%). This is probably because of the strong research tradition that had been established in these departments. Some active and bright research students of these groups had stayed on to become faculty members either immediately after their doctorate or after some post-doctoral work outside the country. The third category of some significance comprises those who were students at the Masters level only - about 16% However, the number is significant only in two departments: Baroda Y (33%) and Delhi (29%).

There were strong reactions from the respondents when the question of 'extent of in-breeding' was raised. On the one hand,

we had such answers from the senior faculty of IISc, Bangalore as "Oh! our students are the best trained in this country. So we cannot get the type of candidates we want from other universities". On the other hand, there were responses from Baroda such as "If we do not take our students, who will take them? Besides, if they are good enough, then what is wrong in doing so? Don't call this in-breeding".

4.4.2 Respondents Trained in Institutions Other than Where Working

Having noted the extent to which the faculty are already known to the departments where they have found jobs, it is important now to also look into the educational background of those who have been drawn from other institutions within the country and outside. This excercise is useful because, as mentioned earlier, it would reflect on the department's recruitment policy. To start with, we would classify them into two categories: those educated in India (but from institutions other than where working) and those educated abroad. Table 4.8 provides the details.

To interpret the figures in Table 4.8 with respect to the institutions from where the respondents have taken their degrees within and outside the country, the following inferences can be made:

i) Baroda X and Y have drawn their faculty from the nearby provincial universities within the same state. (Gujarat, Sardar

TABLE 4.8

EDUCATIONAL BACKGROUND OF RESPONDENTS FROM INSTITUTIONS OTHER THAN WHERE WORKING

UNIVERSITIES	MASTERS		DOCTORATE		POST-DOC		TOTAL NUMBER
	Indian	Foreign	Indian	Foreign	Indian	Foreign	OF RESPONDENTS
BARODA (X)	3	2(14%)	1	1	1	1	14
(Y)	4(33%)	0	1	2	1	1	12
MADRAS (A)	9(69%)	0	6(46%)	0	2	9(69%)	13
(B)	3	0	1	4(44%)	0	6(66%)	9
(C)	1	0	1	0	0	4(66%)	6
BANGALORE	9	0	4(44%)	2(22%)	0	7(77%)	9
DELHI	10(41%)	0	4(16%)	7(29%)	2	16(66%)	24
TOTAL	39	2	18	16	6	44	87
	(44.8%)	(2.3%)	(20.6%)	(18.3%)	(6.8%)	(50.5%)	(100%)

Patel University (SPU) and Bombay .

ii) Madras A, B and C present a regional character with their faculty drawn from universities and research institutions of the neighbouring states except Kerala. (Annamalai, Madurai, Mysore, Andhra, Karnatak, Pune & IIT-Madras).

iii) Bangalore and Delhi in contrast have a national character, the reasons of which, however, being different for the two. The Indian Institute of Science at Bangalore was envisioned to be a 'National Institute of Science'. Delhi university on the other hand has perhaps acquired a national character because, being the capital of the country, it has a cosmopolitan population with several central government offices. The staff of these offices are drawn from all over the country, and their children pursue higher education in Delhi. However, this is only one among several reasons.

The above classification which uses categories such as provincial, regional and national do not apply at the level of the doctorate degree of the respondents. Here the relevant categories are 'Indian' and 'Foreign'. Hence the comparison among departments at this level would be based on these categories. The following types can be discerned.

(i) Baroda X and Y have only two cases of Ph.Ds from within the country and interestingly both of them are from Physical Research Laboratory (PRL), Ahmedabad, i.e., from Gujarat again. Incidentally, PRL cannot be regarded as provincial, as it is

recognised as an 'All India Institution' of high standing. The three instances of foreign Ph.Ds show the change in trend over a period of time. Of the senior faculty, a professor obtained his doctorate from Leeds, U.K., the other two younger faculty members are from Oaklahoma and Rochester (USA). While one of them had taken his Masters from M.S. University, Baroda, the other had gone to Oaklahoma even for his Masters. They both took up jobs in Baroda for non-academic reasons. It was their home town, where they had a house and a large circle of relatives and friends. While one of them has discontinued research, the other works in theoretical physics and continues his research with regular visits to PRL.

(ii) Madras A, B and C have teachers with Indian doctorates in equal number from research institutes and universities. As for foreign Ph.Ds, A and C do not have a single case, but B of Madras, i.e., the theoretical physics department has four from USA - Carnegie-Melon, Syracuse, Rochester and State University of New York. It may be interesting to look for reasons that may explain the occurrence of a greater number of foreign Ph.Ds found in theoretical physics departments in India than in experimental physics departments. It is claimed that while an equal number of Indian students go abroad for doctoral programmes in both experimental and theoretical physics, especially to the U.S. these days, many who return belong to the latter category.

Due to the greater emphasis on applied research in the U.S., chances of staying on longer there to do post-doctoral work or acquiring teaching/research positions are much higher in experimental physics than in theoretical physics. Further, the question of "academic sacrifice" on return is an important factor. Infrastructural facilities available to experimentalists in India stand no comparison with the well equipped laboratories in the U.S. High quality theoretical physics on the contrary, it is believed, can be pursued if one has access to a good library and an effective pre-print and re-print exchange system.

(iii) Bangalore and Delhi have a combination of Indian and foreign doctorate degree holders. Indian degree holders are from research institutes which by definition have better facilities for research. As for foreign doctorates, both the cases from Bangalore are from US (Carnegie-Melon and City University of New York). But of the seven in Delhi, four are from England (Cavendish Laboratory, London and Cambridge) and three from the US (Chicago, Brandies and Florida).

The most important feature of Table 4.8 is that a significant number of respondents across the five departments (with the exclusion of X and Y of Baroda) have had post-doctoral experience outside the country. Post-doctoral work within the country,if at all, has been done in advanced research institutes like TIFR, IITs or Indian Institute of Science etc., where infrastructural facilities are much better than universities in

the country. Post-doctoral work abroad is significant for respondents in Madras A and C and Bangalore.

As already indicated, the availability of funds and the need for additional trained manpower to keep pace with advancing science in the US, and other western countries, enable students with Indian doctorates to get post-doctoral offers for such subjects identified as frontier areas from universities and laboratories abroad. Besides, some of our respondents felt that they too gained in some way, though they did not contribute creatively to the relevant research while abroad. It enabled them to acquaint themselves not only with the frontier areas of research, but also with the latest problems in their own and related areas. At times, under suitable conditions, they could continue to work on these problems on their return. Post-doctoral research experience abroad benefitted them not only academically but also financially. The most important gain is that they acquire the label 'foreign-returned'. In certain cases, their research publications while abroad and the recommendations obtained from internationally known scientists do help them to find jobs in India without much difficulty.

On the other hand, physicists with Indian doctorates in theoretical physics find post-doctoral offers from foreign universities very difficult to obtain. However, the International Centre for Theoretical Physics, (ICTP) in Trieste, Italy, is one place which scientists from third world countries

can visit for short periods of time, where contact with renowned scientists of the world is possible.

In brief, the educational background of the respondents presents two extremes. Baroda on the one end presents a very much provincial character in terms of the background of their faculty members and Bangalore on the other end exhibits a national character. In addition, it has also been inferred that while Baroda prefers to recruit 'known candidates', excellence seems to be the criteria for recruitment in Bangalore and hence there is no hard and fast rule against recruiting their own students. While Delhi comes closer to Bangalore with candidates from various parts of the country, Madras presents a regional picture. The case of "educated abroad" is more significant at the post-doctoral level. This seems true for almost all the departments except the two of Baroda. There seems no significant difference between the theoretical and experimental physicists in our study.

4.5 CAREER PROFILE OF RESPONDENTS

Before one begins to analyse the career profile of the respondents, it is probably essential to have some idea about the hierarchical structure that exists in the four universities in our study. We find that Madras and Delhi have a three tier system, these being lecturer, reader and professor. However, in the three departments of Madras, there is also a provision for

research associates. They are generally UGC research associates or CSIR Pool Officers. They are considered to be post-doctoral fellows and their participation in the department's teaching and other activities is minimal.

In the case of Baroda there are four levels - Assistant lecturer or Demonstrator, lecturer, reader and professor. It was learnt that generally an assistant lecturer is appointed on ad hoc basis on a consolidated salary and is not considered a permanent faculty member of the department. However, all those who joined the faculty in the 50's and 60's when the department was being expanded were initially appointed as assistant lecturers. The same is not the case with the recent recruits who joined directly as lecturers. Most of the earlier faculty had only an M.Sc. degree when they joined the department. They improved their qualifications while on the job and were made permanent lecturers a good 6 or 7 years later.

It however remains unclear as to whether assistant lecturers are non Ph.D. holders, since these two factors do not seem to be systematically related as seen from the data on recruitment or promotions. To many of the respondents, a job immediately after the Master's degree was attractive especially in the 1950's and 1960's. This was mainly due to rapid expansion of universities and a corresponding demand for qualified candidates. Besides, university jobs those days were highly respected in the view of respondents. It was only later that they realised the

stagnation in the profession, but then it was too late for them to look for alternatives. Initially promotions were primarily against vacancies and there were few incentives available to them. In 1983, the implementation of the merit-promotion scheme had induced many to register for a doctorate degree and as we shall see in the following section, the introduction of this scheme did give rise to a significant change in the structure of departments.

Bangalore also has a four tier system; it has positions of lecturers, assistant professors, associate professors and professors. Data show that vertical mobility in this department does not necessarily mean passing through all the three tiers; promotions are possible by jumping over tiers. Besides, direct recruitment of even fresh doctorates to assistant professorship is prevalent. In fact, at the time of the study we found that the department had only professors and assistant professors with no associate professors or lecturers.

These being the kinds of hierarchical structure existing in the four universities, the task is to make a study of the number of years taken by our respondents to move from one level to another. Such an analysis would give us some idea about the development and stagnation of the departments. Differences that may exist between the earlier recruits and the later ones will also be highlighted.

The striking feature of Table 4.9 is the difference in the

TABLE 4.9

VERTICAL MOBILITY OF RESPONDENTS: AVERAGE NUMBER OF YEARS SPENT IN DIFFERENT LEVELS

UNIVERSITIES	PROFESSORS				READERS			LECTURERS		RESEARCH ASSOCIATES
	AL/RA	L	R	P	AL/RA	L	R	AL/RA	L	
BARODA (A)	6	11	16	3	6	14.5	5	8	12.5	-
(B)	6.5	3.5	5	8	7	16.5	4	-	4	-
MADRAS (A)	-	6.5	7	7	-	6.5	4.5	-	6	-
(B)	-	6	8	11	-	9	2	-	3	1.5
(C)	-	10.5	3.5	12	-	6.5	6	3	1	4
BANGALORE	3	3	5*	6	-	5	1.5**	-	-	-
DELHI	-	6	13	4	-	10.5	6	-	1	-

*As mentioned, this contains two categories: Assistant professors and Associate Professors. The break up of years in these two categories is 6.5 and 4.5 years.

**This refers to Assistant Professors only. There were no Associate Professors.

mobility pattern of professors and readers. While for the professors, mobility from the lecturer's grade to the reader's grade seems to have been easier than from the reader's grade to the professor's, for the readers in the study, mobility from the lecturer's grade to readers level itself seems to have been difficult. Two factors can explain this phenomenon. The present professors must have been the early recruits during the initial years of expansion of the department and as such mobility from one grade to the other must have been easier. The tenure of their lectureship was long probably due to insufficient qualifications. The other factor could be the merit promotion scheme. Promotions were always against vacancies and this scheme provided a way out of the resulting stagnation. However, there is no single factor that explains this phenomenon across all departments. As noted in the earlier section on educational background, the Delhi respondents had entered the department with doctorate degrees and at times with post-doctoral experience too. In 1962 when this department was recognised as a Centre for Advanced Study, there was considerable expansion. Recruitment of a number of faculty members during a particular period could make promotions difficult later and give rise to long tenures of its faculty in a single grade. Staggered recruitment is generally preferred to enhance the development of departments.

If figures shown in Table 4.9 represent Bangalore and to

some extent C of Madras as being different from the pattern described above, it could be attributed to the age of these departments. Bangalore was about 15 years old and C of Madras 18. Both of them had fewer faculty members, which could have facilitated their mobility. It should also be noted that Bangalore has had staggered recruitment which could be an additional reason for easier mobility.

What needs special mention here is the growing trend to work as research associates before one joins as a permanent faculty. However, these positions are treated as post-doctoral ones and do not guarantee permanent faculty positions. In contrast, the earlier system of assistant lectureship did guarantee permanent positions. An assistant lecturer was given teaching duties and was considered a faculty member, though not a permanent one. The research associates we met had an undefined role and status in the departments and remained almost marginal members.

In sum, we can say that the departmental requirements and the research tradition do have a bearing not only on the minimal qualification essential to join the department but also on their vertical mobility once in the department. However these requirements do undergo change and modification. We again have Baroda at one end where a research degree was not considered essential in its formative years as the main focus was on teaching. Though emphasis on teaching remains, change with

respect to minimum qualifications to enter is evident. Though a doctorate is preferred it does not seem a very rigid necessity. On the other hand with the exclusive research tradition at Bangalore, one finds from its very inception the need for eligible candidates not only to have full-fledged doctorate degrees but also some post-doctoral experience.

All these above discussed organisational features have a direct bearing on the mobility of respondents. While in Baroda the entry point is not very strict, promotions are largely based on the output of one's research activity. This situation thus creates a paradox. One finds greater stagnation here as respondent's have to religiously pass through all the grades within the structure. In contrast Bangalore's emphasis on research is well directed towards providing the necessary infrastructure and faculty members are evaluated on their contribution to research. Vertical mobility here is thus relatively easier, and a faculty member need not necessarily pass through all the four grades within the structure.

The remaining four departments of Madras and Delhi have a mixed tradition of both teaching and research. Thus they are particular about a research degree for entering the department. However in contrast to Bangalore, where the directed and specific research tradition of the department has taken care of the mobility of its respondents, factors external to the department have helped to minimise stagnation in Madras and Delhi. This can be attributed to some general programmes of the UGC, for

example, Centres of Advanced Study scheme where our Delhi department has been identified, the Special Assistance Programme in which Madras A figures etc. These schemes not only bring extra funds to the departments to promote research, but also provide for increased number of posts in the different cadres.

4.5.1 Factors Affecting Career Mobility

It is interesting to note the changes in the compositional structure of the seven departments between 1980 and 1986 (Table 4.10). This exercise has been possible with the help of the career profile of respondents as given by them. Three distinct stages seem to function in the birth, maturation and aging of the departments.

(i) The first stage where the percentage of professors is low, faculty at the readers grade show medium strength and the strength in the lecturers grade is rather high. (Baroda A & B - 1980).

(ii) The second stage also has low professional strength, but high at the readers grade and medium to low at the lecturers level (Delhi - 1980; Madras A - 1980; Baroda A & B - 1986).

(iii) The third stage is characterised by high professorial strength, medium strength at the readers' grade and low at the lecturers' level (Madras B&C - 1980; Bangalore - 80 more sharply 86; Madras A - 1986 and Delhi 1986).

However, a fourth stage is also indicated with the further

TABLE 4.10

PROMOTION AND STRUCTURAL CHANGE IN SAMPLE SIZE

UNIVERSITIES	1980 SAMPLE SIZE			1986 SAMPLE SIZE				1986 TOTAL NO. OF RESPON-DENTS	NUMBER PROMO-TED	REAL SIZE	PERCENTAGE REAL SIZE PROMOTED
	P	R	L	P	R	L	R.A.				
BARODA (X)	0	5	9	3	7	4	-	14	8	25	32%
(Y)	1	1	9	2	8	1	-	12	8	15	53%
MADRAS (A)	2	4	5	5	3	5	-	13	5	16	31%
(B)	3	2	1	3	1	3	2	9	1	9	11%
(C)	2	1	1	2	2	1	1	6	1	6	16%
BANGALORE	2	2	1	6	3	0	-	9	3	10	30%
DELHI	3	16	3	14	8	2	-	24	14	52	27%

shrinking of the readers' grade. The recruitments are high at the lecturer's level anticipating retirement of senior faculty members. Some indications for this speculation are drawn from the structure of Madras A,B and C - 1986.

This kind of growth is not consistent with the UGC norm of 1981 that requires the percentage of senior teachers (professors and readers)out of the total teaching staff to be 50%. (Report of the Review Committee on UGC programmes, 1981: 20). How then can this be accounted for? What are the modifications allowed by the UGC? Some explanation can be offered in terms of the Merit-Promotion scheme of the UGC.

4.5.2 **Merit-Promotion Scheme: Role in Structural Change**

This is an important programme of faculty development first introduced by the UGC in 1983. "The scheme aims at providing suitable opportunities to teachers working in universities and colleges for career advancement in recognition of their significant contributions in teaching, research and related educational activities. Under this scheme, a teacher after a critical assessment of his work at the end of a specified period can be promoted to the next higher level; the promotion to be treated as personal to the incumbent and the resulting vacancy to remain unfilled. It is felt that this scheme would go a long way in raising standards of higher education by encouraging university and college teachers to put in their best efforts in their work. (UGC - Development of Higher Education and Research

in Universities, 1980-85: 25).

Refering to details of Table 3.1 (Chapter III) and differences shown in Table 4.10 with reference to the real size and the sample size, we find that Baroda X and Y, Madras A and Delhi have benefitted most from the introduction of the merit promotion scheme. In these departments anything between 30% and 50% of the faculty promotions have been primarily due to this scheme. In Baroda X, 3 readers and 5 lecturers have been promoted from our sample of 14, while in Baroda Y 1 reader and 7 lecturers in our sample of 11 have been elevated. In the case of Madras A, 5 out of 13, 3 out of 10 in that of Bangalore and 14 out of our 24 respondents in Delhi have benefitted. It should however be noted that our sample size have not covered all target respondents and hence there is a probability that the percentage having actually benefitted through the Merit-Promotion scheme could be much higher.

New recruits have been primarily in Bangalore where 4 faculty have joined since 1980. Two have joined Baroda Y, 2 each in Madras A and B and 5 Delhi. These recruitments have been by and large at the lecturers level, though we have instances of a professor being recruited in Baroda Y and an Associate Professor in Bangalore.

It may be noted that with the revised pay scales for university teachers, this scheme of merit promotion was discontinued. In protest the University teachers went on a

prolonged strike in August-September 1987. This was not the only reason why they did so; they had several other grievances with regard to the various conditions that went with the revised pay scales. In the compromise that finally ensued, the UGC assured the teachers that the earlier merit-promotion scheme would continue, although under disguise. Accordingly, teachers with 13 years of teaching experience and a Ph.D. degree would be eligible for the "Reader's grade" if they cannot make it to 'Reader's Post' in open competition. There was to be a similar provision at the level of the professor's grade. Under the 1983 scheme, readers with 10 years experience at that grade were promoted to professor's positions. This scheme has thus caused sudden changes in the compositional structures. Their consequences on the teaching and research activities of the university teachers would be discussed later in the relevant sections.

In this chapter, we have attempted to highlight the differences in the organisational features of the seven departments. We have shown that recruitment of faculty members and their career mobility are very much in line with the goals and needs of the departments. While Baroda X emerges as primarily a teaching department, Bangalore exhibits itself as a purely research-oriented one. The remaining five are mixed departments in the sense that they do both teaching and research in various proportions. Stagnation of faculty members is a fairly serious problem in teaching departments, however, extrinsic

factors such as Merit-promotion scheme have been of significant help in this regard.

The analysis of the infrastructural facilities available in these departments and the respondents' reaction to them have yielded interesting observations. While Baroda X and Bangalore seem highly satisfied with the facilities available to them, the respondents of the remaining departments are generally highly dissatisfied with facilities in their own departments. Respondents have identified several problems with regard to the technical support facilities, while describing the overall work culture in their respective universities.

Nature of headship and the organisation of departments have been examined in this chapter. The analysis shows that the practice of rotation of headship wherever it exists, operates differently in different universities. It was found that no system of headship is inherently successful as its effectiveness depends not merely on the goals and obligations of departments but also on the overall 'culture of science' of the members of the faculty.

Despite various limitations within their organisational settings, our respondents do engage themselves in research apart from fulfilling their teaching requirements. We take up aspects related to research activity in the following chapter.

CHAPTER V

DEPARTMENTS AND SCIENTISTS: RESEARCH PROFILE AND PRODUCTIVITY

This chapter focuses on the research interests of the physicists beginning from their doctoral background. Their shifts in research interests and the factors affecting such shifts are also analysed. However, research activity though presented in the respondents' perspective is objectively measured in terms of their output - i.e. research productivity. With the help of the list of publications provided by the scientists, some preliminary analysis of productivity patterns is also undertaken in the second section of this chapter.

SECTION I

5.1 INITIATION INTO RESEARCH: DOCTORAL BACKGROUND OF RESPONDENTS

Effectively, a scientist's research career starts with his thesis problem for the doctorate degree. During this period he undergoes the essential training to launch his independent research career and the degree qualifies him to do so. While it is to some extent crucial as he selects the research area to which he tries to contribute, it is however not necessary that he continues to work in the same area. We now analyse the research careers of our scientists with retrospective effect from their doctoral programmes. This would give us some idea on the

research tradition that scientists bring along with them to the institution.

From the details given in Table 5.1 the following inferences can be made: firstly, a majority of the respondents - about 69% have taken their doctorate degrees as full-time students indicating that they had opted for a career in teaching and/or research. However, many teachers have also taken their doctorate degrees while on job. They belong to the two departments of Baroda and C of Madras. About 7% of the sample still do not have a doctorate degree. These respondents are primarily from the departments of Baroda and Delhi. It is probably essential to look into details that have affected their status.

As evident from the table 5.1 there are six such respondents of whom five belong to Baroda. It was found that they were all senior in terms of age (above 50 years) and were all in the readers grade. The reasons given by them for not registering for a research degree may be broadly classified as (i) personal limitations (ii) institutional limitations. They referred to indifferent health under personal limitations. Spending long hours standing in the laboratories, would cause physical exhaustion which they felt their age could not take. One respondent said that he was interested only in spectroscopy if at all he had to do research, but his eyesight was already failing and it would be impossible to spend long hours in the

TABLE 5.1

DETAILS OF DOCTORAL BACKGROUND OF RESPONDENTS

UNIVERSITY		NO DEGREE	FULL-TIME	PART-TIME	TOTAL NUMBER OF RESPONDENTS
BARODA	(X)	2(14%)	6(43%)	6(43%)	14
	(Y)	3(25%)	3(25%)	6(50%)	12
MADRAS	(A)	0	12(92%)	1(8%)	13
	(B)	0	9((100%)	0	9
	(C)	0	3(50%)	3(50%)	6
BANGALORE		0	9(100%)	0	9
DELHI		1(4%)	18(75%)	5(21%)	24
TOTAL		6(7%)	60(69%)	21(24%)	87

dark room. They expressed that they had no incentive in their early ages of the career and when the Merit Promotion scheme was introduced, they were already in their middle ages. It seemed a coincidence that all these respondents mentioned that they enjoyed teaching and were not ambitious about promotions. It is pertinent to also include a different kind of response here. One respondent from Baroda reacted to the question of research by saying that research need not necessarily be related to a degree. He does research out of curiosity or to learn some new techniques and from time to time anyway experiments with ideas. But this, he said, in no way meant that he was a seasoned or a regular researcher.

Institutional limitations largely refer to few incentives available for improving qualifications. The Baroda physicists feel that a period of long strenuous work is not worthwhile if they are not rewarded with promotions. One respondent very strongly reacted that with heavy teaching duties it was difficult to engage in concentrated research. [Teaching load of the respondents of Baroda as shown earlier is significantly high]. He further added that provision for study leave was absent earlier,and when UGC did introduce the scheme, he had little enthusiasm. The alternative was to register in the same department with a colleague. This he found uninteresting because the department, he feels has not been able to offer even a good M.Phil programme and hence a good Ph.D. was unimaginable. With

first-hand knowledge about the kind of research pursued by his colleagues, some of these respondents felt that Ph.D. research in this department was a sham, some sort of 'museum-piece work' with little concern for utility and hence opted out of a Ph.D. degree.

The single case without a doctorate degree in Delhi university is an involved story about the tussle of the respondent with the first head of the department -- Prof. D.S. Kothari. In the respondent's opinion, he was not given any preference with respect to the research problem he wanted to work on, or the supervisor he wished to work with. Later, he joined the department as a lecturer but faced several hurdles at various stages that finally prevented him from submitting his thesis in the same department or elsewhere. Notwithstanding, he feels that the professor interfered with all chances of his professional mobility when he had offers from other scientific institutions. Though it is to some extent acknowledged that extra-academic factors such as personal biases do have some impact on the career of the individuals, whatever the profession; yet the details of this case can not be considered as complete. It could as well constitute a case study in itself.

The teachers who were part-time Ph.D. students were all on jobs either in the same departments or in colleges close by. They have worked for their doctorates in the late 70's or in the early 80's. Interestingly none had registered for a doctorate after the 1983 when the Merit Promotion scheme was announced.

Conversely, they were ready to be considered for promotion having improved their qualifications.

5.2 FACTORS AFFECTING DOCTORATE DEGREE PROGRAMME

Factors affecting or having affected the doctoral programmes of our respondents relate to three main aspects: choice of place (university, institute) of work, choice of thesis supervisor for their research and choice of research problem to be pursued. With reference to these aspects, it was found that factors varied for those who had done a part-time Ph.D. in contrast to those who had done a full-time programme; and those who worked in India for the degree and those who worked abroad.

5.2.1 Part-time Doctorates

As discussed in the earlier section, invariably most of them had registered in the same departments where they are working as it was much easier to be both on the job and pursue a degree. Once within the department, they had other limitations. They knew about the research interests of their colleagues. For the Baroda respondents, very few colleagues were eligible to guide and hence one among them had to be chosen. Further, being member of the same department they were conscious of departmental politics and social affiliations, and hence they had to make their choice of thesis supervisor carefully. These factors then considerably curtail their freedom with reference to the choice of thesis supervisor or research area. However, some

respondents did not consider these as serious limitations, as their primary aim was to merely improve their qualifications and benefit from the Merit Promotion scheme.

5.2.2 Full-time Doctorates

Factors vary for those who have worked in India and for those who have gained doctorate degrees from abroad with respect to the above three choices mentioned. We would first consider the case of those who have Indian doctorates. Four factors have affected their choice of institutions. They are (i) attraction to dynamic personalities (ii) knowledge about leading institutions (iii) availability of resources and (iv) availability of thesis supervisors.

Taking the first, dynamic personalities like Prof. G.N. Ramachandran (in A of Madras) and Prof. D.S. Kothari (in Delhi) who were leaders of active research groups have influenced some respondents. They were exposed to them as M.Sc students of these departments, and developed a strong desire to work under them. Besides the above mentioned names, the case of Prof. A.N. Mitra (currently at Delhi university) needs special mention. Prof. Mitra was earlier teaching at Aligarh Muslim University. It is said that when he shifted to Delhi, a number of his M.Sc. students at Aligarh, sought admission for the Ph.D. programme in Delhi University primarily because they wanted to work under Prof. Mitra for their doctorate degrees. There are a few who were impressed by such personalities when they visited the

universities to give lectures, or were being constantly talked of by their teachers.

The story is slightly different for one respondent of Madras A. He had joined the doctoral programme in IIT Madras and one day in the library came across the proceedings of a symposium held by the physics department of Madras university. He found names of international celebrities and found the topics of research very interesting. Fascinated by these, he went to the department at Madras University to gather more details. He then met the head and straightaway expressed his desire to register for the Ph.D. degree. He says that matters were arranged within a week and he discontinued his programme at IIT Madras to join the department of Physics at Madras University.

Once a member of the team, our respondents say, students were largely assigned research problems to work on, which generally was part of the research programme of the team or group. This seems to be true not only for our Delhi respondents but for those who had taken their doctorates in the three departments of Madras and that of Bangalore as well.

The second factor that had influenced the choice of our respondent's doctoral programme was institutional visibility. They generally had information about institutions that are doing well like TIFR or Indian Institute of Science, Bangalore and also on teams or departments that were active. Respondents also had some idea about sufficient financial resources of these

institutions and the freedom students enjoyed to work the way they wanted. Besides, these institutions they say, were regarded highly amongst the scientific community. The respondents mainly referred to advanced research institutions like IISc, TIFR or the IIT's. However, one of our respondents has some additional remarks to make in this regard. He too had joined TIFR with such illusions. He registered with one scientist, who gave very little attention to students. After a couple of years, his supervisor left the institution and went abroad. He then had to register with another scientist in the same institution but says that the new supervisor was indifferent towards his work. This experience was then frustrating for he had progressed very little with his work. The respondent then wrote to a few scientists in the U.S. who had visited TIFR, enquiring about his chances to work with them for a doctorate degree. He thus left TIFR when he got some favourable replies and has returned to India after completing his doctorate.

The third factor mentioned was the availability of resources and facilities. It is strange but true that some of our Baroda respondents said that they chose the area of research and supervisor (in the same department though) based on the fact that he had a well-established laboratory, reasonable experimental facilities and contacts that ensured continuous inflow of money for research. They thus felt that research would be uninterrupted and of some standard.

The last factor mentioned is the availability of guides for research. Some respondents said that they not only developed clear ideas about the areas they wanted to work in but at times also about the specific problem they wanted to work on. However, they say that one is not always lucky. The respondents who had registered in Delhi university in its earlier days, found that there were no good experimental physicists with well equipped laboratories. As a result they had to modify their orientation which led some to register even with theoretical physicists. They however added that such compromises did benefit them as they meant less dependence on money or on people.

Shiva and Bandhopadhyaya (1980) make a similar observation in their study of 73 physicists. Indian scientists, according to them face external constraints in the choice of their research problem. They are hampered by the limited equipment available for their work in India. To illustrate this, they quote the response of a scientist who said "my interest was to work in Solid State Physics. However, there was no liquid helium available in the department in those days. So I decided to change my interest slightly" (Shiva & Bandhopadhyaya, 1980: 577).

5.2.3 **Foreign Doctorates**

Among those who went abroad, some respondents have had clear and directed ideas about the research area, problem, scientists and university for their doctorate degree. For the rest,

availability of scholarship and other situational factors has been responsible for directing their choice of place for a doctorate degree.

Taking the first, we found that respondents from Madras A & B and Delhi (where foreign doctorates are prominent), had made priority lists when they applied abroad. Some were able to obtain scholarships from such universities they desired to join while others say that they had to make mild compromises.

The second factor of situations affecting choice of place are largely true of the Delhi respondents. Exposed to all the National Fellowship schemes and international exchange programmes like the Commonwealth Fellowship, I.C.I. Fellowship etc., some respondents tried to go abroad through such schemes. In doing so, the choice of countries and/or universities too were limited. These fellowships could be availed of only in England, at times in some European countries. Thus though some of them had obtained fellowships from U.S. universities which they desired to join, yet went to England with such fellowships like the ICI scholarship. This benefitted them much more, as their passage cost was also taken care of besides giving them greater prestige for they were selected in a national competition. This is true of the junior faculty who had been to the UK. The explanation for some of the senior respondents who had been to Cavendish, Oxford is different. These laboratories and universities were the leading ones in frontier areas during their times and hence their

choice was purposive. It also gave them great prestige and honour once back in the country.

Besides the above mentioned factors, there are some specific to women scientists. Marriage migration, both within the country or to foreign lands has in a way affected their career choice in order to remain in the same place where their husbands were working or studying. They had to make the best of what was available. For other women who were single or had pursued higher studies before marriage nearness to home forced them to join certain institutions preferably within the same town/city of their parents' home. Thus two respondents joined PRL Ahmedabad and later found jobs in Baroda. Another woman physicist from Madras narrated that she had to join National Chemical Laboratory in Pune because it was her home town. The institution had only two units in physics and she had to choose one among them. The issue is not whether these were good institutions or not, the above instances only highlight the fact that women as such have lesser freedom and more constraints about moving far away from their family to pursue higher education. The status of women in science is an issue in itself, and we will not go further into this debate as our study was not designed towards studying this issue.

5.3 RESEARCH INTERESTS OF RESPONDENTS

While the doctoral degree is an initiation into research for one who aspires to take up research as a career, research

interests get shaped and modified once he enters an institution to work as the prevalent conditions of that institution become more relevant and enduring. To quote Ziman who refers to Lemaine "The success of a laboratory does not depend on features of its organisational pattern such as democracy, authority or autonomy; it depends on the choice of domain and subjects for research. Whether this choice is made by a powerful leader, or by a collective decision, it remains the principal factor in the policy of any quasi-academic research organisation". (Ziman, 1987: 94).

What then are the research areas in which our respondents work? Data analysis shows that research interests for the theoretical physicists and the experimental physicists are not the same. We could identify about ten areas in theoretical physics and eight areas in experimental physics in which our respondents work. The main areas in Theoretical Physics are:

1. Field Theory and Quantum Mechanics
2. Astrophysics
3. General Relativity and Gravitation
4. Nuclear physics and Fusion research
5. Bio physics
6. Solid State physics
7. Statistical Mechanics
8. Mathematical physics

9. Computer physics
10. Atomic and Molecular physics.

Before proceeding to discuss the break-up of the research interests of the faculty members, it is essential to note certain departmental features. One of the departments of Madras, namely B of Madras is totally devoted to teaching and research only in theoretical physics. The department of physics at Delhi during its initial years of establishment promoted research in theoretical physics and became known more specifically later for its work in the area of Astrophysics. However, while the former continues to remain a department of theoretical physics, the latter has many experimentalists too on its faculty, recruited in the process of expansion of the department. We would now look into the distribution of faculty from the seven departments in accordance with their research interests.

Looking at the details in Table 5.2, we find that 30% of the respondents work in Field Theory and Quantum Mechanics. They are mainly from Madras B and Delhi. The next highest concentration is 14%, which refers to respondents engaged in research problems in the area of Nuclear physics and Fusion Research. They are from Baroda, Madras C and Delhi. One probable reason for this interest for the Baroda scientists, is due to its proximity to PRL and Institute for Plasma Research, both located in Ahmedabad, which is about four hours drive from Baroda. These research laboratories have been established under CSIR and DST. As for

TABLE 5.2

RESEARCH INTERESTS OF RESPONDENTS - THEORETICAL PHYSICS

UNIVERSITY		1	2	3	4	5	6	7	8	9	10*	TOTAL	TOTAL NO. OF RESPONDENTS
BARODA	(X)	1	-	-	1	-	-	-	-	-	1	3(21%)	14
	(Y)	-	-	-	1	-	-	-	-	-	-	1(8%)	12
MADRAS	(A)	-	-	-	-	1	2	-	-	-	-	3(23%)	13
	(B)	4	1	1	-	-	-	2	-	1	-	9(100%)	9
	(C)	2	-	-	1	-	1	-	-	-	-	4(66%)	6
BANGALORE		-	-	-	-	-	-	-	-	1	-	1(11%)	9
DELHI		6	4	1	3	-	2	3	-	-	2	21(87%)	24
TOTAL		13	5	2	6	1	5	5	-	2	3	42(48%)	87
		30%	12%	5%	14%	3%	12%	12%	-	5%	7%		

*NUMBERS REFER TO RESEARCH AREAS LISTED IN THAT ORDER IN THE TEXT

the other two departments, Madras C is the department of Nuclear Physics and hence the physicists' interest in Nuclear physics. Scientists in Delhi work in diverse areas in theoretical physics and hence incidence of some in Nuclear physics or Fusion Research. Besides these two areas, certain other fields of some significance are Astrophysics, Solid State physics especially Crystallography and Statistical Mechanics. All these three areas have 12% of the total respondents working in each of them.

Analysing the details departmentwise, it should be noted that Bangalore is primarily engaged in experimental research and so is Madras A to a large extent. However, it is also relevant to point out here that the few theoretical physicists in these departments work on areas which are well within the main focus of the departments. Unlike them, the Baroda respondents work in isolation and have little in common with the experimental physicists of their departments. As for the two departments mainly devoted to theoretical research i.e. Madras and Delhi,while about 50% of the respondents of Madras B work on problems in Field Theory and Quantum Mechanics, the interests of the Delhi scientists are diffused over almost all the areas. It ranges from Astrophysics and Field Theory to Solid State physics and Statistical Mechanics.

Some discussion about the establishment of the departments may be in order, before one moves to an analysis of the data on research of experimentalists. It has been noted that a greater

number of the physicists of Baroda X work on problems in Solid State physics especially Crystallography. The first head of Baroda Y was interviewed. This professor had taken his doctorate degree from Leeds, U.K., specialising in Spectroscopy. He joined as the head of the new department on return. In order to pursue his research interests, he systematically tried to develop the laboratory and build a team. Thus most of the researchers from Baroda Y work in Atomic and Molecular physics especially in experimental Spectroscopy.

The three departments of Madras have very clear perspectives. As discussed earlier, Dr. G.N. Ramachandran moulded the physics department (now Madras A) towards advanced research in Crystallography and Biophysics. Madras B is directed towards research in theoretical physics and Madras C was established to solely concentrate on a frontier area then ('69) - Nuclear Physics. Thus the departments of Madras had not only emphasised on research activity from the beginning, but had clear directions about the specialisations they were to concentrate on too. Unlike these, the physics departments at Baroda were established primarily as teaching departments and hence research activity was dependent on the interests and initiatives of the individual scientists who were recruited to the faculty.

Bangalore was established primarily as a research department. Its goals and objectives were clear and recruitment has been in accordance with the overall perspective of the

department. Here, research is concentrated primarily in the area of Molecular Biophysics. Delhi was initially a teaching department but importance was also given to build a group of theoretical physicists in the early years. However, the perspective became more flexible and hence there has been greater diversity in recruitment with expansion.

With this background, let us look at the key areas of research interest in experimental physics that have been identified. They are as follows:

1. Atomic and Molecular physics
2. Solid State physics and Crystallography
3. Electronics and Instrumentation
4. Biophysics
5. Solar Energy
6. Atmospheric physics
7. Low Temperature physics
8. High Energy physics

Table 5.3 shows that about one-third of the total number of experimentalists do research in the area of Solid State physics and Crystallography. But, the majority of them belong to Baroda X and Madras A. As this observation seemed intriguing, given the history of both the departments, some attempt was made to gather information about the research area. It was learnt that Solid State physics is generally more popular especially X-ray Crystallography, as one can work on a range of problems with

TABLE 5.3

RESEARCH INTERESTS OF RESPONDENTS - EXPERIMENTAL PHYSICS

UNIVERSITIES	I	II	III	IV	V	VI	VII	VIII	TOTAL	TOTAL NO. OF RESPONDENTS
BARODA (X)	3	5(55%)	1	-	-	-	-	-	9(64%)	14
(Y)	5(63%)	1	-	1	1	-	-	-	8(66%)	12
MADRAS (A)	3	5(50%)	-	2	-	-	-	-	10(76%)	13
(B)	-	-	-	-	-	-	-	-	0	9
(C)	-	1	2	-	-	-	-	-	3(50%)	6
BANGALORE	-	1	-	7(81%)	-	-	-	-	8(88%)	9
DELHI	-	2(28%)	-	1(14%)	-	2(28%)	1	1	7(29%)*	24
TOTAL	11	15	3	11	1	2	1	1	45(52%)	87
	(25%)	(33%)	(7%)	(25%)	(2%)	(4%)	(2%)	(2%)	(100%)	

*Some experimental physicists also do research on theoretical problems. The vice versa is not true. Hence the overlapping of some physicists in both areas and discrepancy with respect to Delhi respondents when Tables 5.2 & 5.3 are compared.

simple instruments and also with sophisticated ones. The difference lies in the choice of crystals. While the scientists in Baroda X are interested in studying the structure of metal crystals, the physicists of Madras A are engaged in studying more complicated structures like that of biological molecules.

Closely following are the research areas of Atomic and Molecular physics and Biophysics. Bangalore was set up basically to promote research in Molecualar Biophysics and hence 7 out of 8 physicists working on experimental research in this department are engaged in this area. It is evident from Table 5.3 that physicists in X and Y of Baroda also work on problems in Atomic and Molecular physics. The base of Baroda X is however Baroda Y, from where some of the faculty of Baroda X have taken their research degrees. These scientists unlike the Biophysics concentration of Bangalore, have worked under a single professor who took initiative to build a laboratory to pursue his research interests. Some details of this phenomenon have already been discussed. Thus Baroda Y has no long term departmental perspective for research unlike the department of Bangalore. Hence there seems to be little importance given to training students or inducting new faculty with similar research interests.

The two departments that do not fit into any of these classifications are C of Madras and Delhi. Research both on theoretical and experimental aspects of Nuclear physics are

pursued by the physicists of C of Madras. They also have consistent interest in instrumentation but it is directed towards catering to their research needs. Thus in terms of directedness of research interests Madras C would occupy a place closer to Bangalore. Delhi on the other hand has diffused interests with scientists working in all areas from Crystallography to Atmospheric physics. This has been largely due to expansion with diffused goals.

With this background of the research interests of our respondents, we can now proceed to compare them with the 'Thrust Areas' identified by funding agencies like the DST. Research and Development budget of these agencies are allotted according to the research areas identified and are accessible to scientists working in the country. The thrust areas of the Department of Science and Technology are broadly classified under four headings (a) Life Sciences (b) Chemical Sciences (c) Physical Sciences and (d) Engineering Sciences. It was learnt that due to the increasing nature of'interdisciplinary science' some areas overlap across the broad classifications made.The areas mentioned under the 'Physical Sciences' by DST are:

1. Atomic and Molecular physics
2. Nuclear physics
3. High Energy and Plasma physics
4. Optics and Laser physics

5. Condensed matter especially Superconductivity
6. Astronomy and Astrophysics
7. Atmospheric physics especially Monsoon studies
8. Molecular Biophysics (under life sciences). [DST, 1984-85 & 1988]

In the opinion of some practitioners of physics some additions were made to the areas identified by DST. Most of the areas mentioned by DST were regarded as largely experimental in nature and hence the areas added were frontier areas in theoretical physics. They were :

9. Nonlinear physics and Chaos
10. Particle physics.

Table 5.2 shows that 14% of the scientists working in theoretical physics are interested in problems in Nuclear physics and Fusion Research. These scientists were from Baroda X and Y, Madras C and Delhi. In the opinion of some physicists, while Fusion Research may be called a frontier area, general problems in Nuclear physics are not regarded as very exciting these days. Three areas of Astrophysics, Solid State physics and Crystallography, and Statistical Mechanics showed 12% of the respondents working in each of them. Some areas of Astrophysics like the study of Early Universe and Galaxy Formation are considered as frontier areas, but Solar physics has acquired enormous attention due to its application value. While Nonlinear Theory and Chaos under Statistical Mechanics are considered as

frontier areas, Crystallography under Solid State physics had acquired more importance in its experimental dimension to study structures of complicated molecules (like biological molecules) and hence some importance to its study theoretically too.

In terms of the areas of interest of the experimental physicists, 33% work in Solid State physics. The other significant areas are Atomic and Molecular physics and Biophysics. Of these we have found the latter two being listed as Thrust Areas. The scientists engaged in them are primarily from Madras A and Bangalore. It may also be recalled here that Bangalore has been identified as a Centre of Advanced Study by the UGC and Madras A (once an advanced centre) continues to get funds from UGC under the Special Assistance Programme.

To state the main inferences that emerge from this discussion on the research interests of our physicists, we find that for Bangalore and to some extent Madras C research problems are very clear. The department functions as a whole and research problems chosen require contribution from all the members. The interests of the respondents are directed in accordance with the research goals of the department. Conversely, we find in the two departments of Baroda that research is primarily dependent on individual interests of faculty members. Some of them have been successful in getting a few colleagues interested in their problems and have built some form of a group around them.

Madras A and B fall closer to Bangalore and Madras C. Though they do not function as whole departments with respect to research activity, many faculty members with similar interests are present within the department and hence have greater chances of interacting. With a large faculty strength having diffused research interests, physicists of Delhi have very few chances of functioning as wholes. Research activities are centered around some individual scientists and hence the department presents a picture closer to that of Baroda.

5.3.1 Shifts in Research Interests of Respondents

It can be discerned from Table 5.4 that 9% of the respondents are not engaged in active research of any kind. They are mainly from the two departments of Baroda. It may also be noted that a significant percentage of the physicists - 29% pursue the same research area with which they had begun their career with a doctorate degree. The remaining 62% have diversified, modified or changed their interests. Those pursuing research in the same area are primarily from the departments of Bangalore, Baroda X and Madras A. It is interesting to note that not only are these three departments basically involved in experimental research, but are also engaged in similar areas of research - Solid State physics, especially Crystallography and Molecular Biophysics. It was understood that in experimental research, building a laboratory is a difficult job and consumes a lot of time. Hence switching fields is not very easy. Both

TABLE 5.4

NATURE OF SHIFTS IN RESEARCH INTEREST OF RESPONDENTS

NATURE OF SHIFTS	BARODA		MADRAS			BANGA-LORE	DELHI	TOTAL
	(X)	(Y)	(A)	(B)	(C)			
No. Research	4(29%)	3(25%)					1(4%)	8(9%)
Same Area	6(43%)	3(25%)	6(46%)		1(17%)	4(44%)	5(21%)	25(29%)
Related shift	1(7%)	1(8%)	2(15%)	5(56%)	4(66%)	3(33%)	3(12%)	19(22%)
More specialised	2(14%)	1(8%)	3(24%)	1(11%)	1(17%)	2(22%)	3(12%)	13(15%)
Same Methodology, problem different	-	1(8%)	-	-	-	-	1(4%)	2(2%)
Drastic shifts	1(7%)	3(25%)	2(15%)	2(22%)	-	-	11(46%)	19(22%)
Specialisation same, problems varied	-	-	-	1(11%)	-	-	-	1(1%)
Total	14 (100%)	12 (100%)	13 (100%)	9 (100%)	6 (100%)	9 (100%)	24 (100%)	87 (100%)

Madras A and Bangalore right from the beginning had long term goals and had directed their activities towards building a research programme. However, as Ziman says "Persistence within a specialised area of research is not necessarily disadvantageous to the individual or to the progress of science." (Ziman, 1987: 102). For he explains that the frontiers of science are constantly redrawn and problems considered tough at one point of time suddenly get solved with new methods or techniques. While almost a similar percentage of the faculty members in the three departments mentioned, Baroda X (43%), Madras A (46%) and Bangalore (44%), have continued to work in the same area of research,it may be pointed out that, these three departments vary in terms of their status and recognition. As mentioned above Baroda X did not have directed research goals like Madras A or Bangalore.

Among those who have changed their research interests we find an equal percentage of respondents who have made related shifts or drastic shifts (22% in each category). Those who have made related shifts have basically diversified their interests in order to use instruments/techniques available or have tried to solve problems in diverse areas in order to use a single method. Instances of such shifts were found among Baroda Y scientists who attempted to study diverse problems with the methods of Spectroscopy. Such diversification is however evident among scientists of almost all departments. However, such

diversifications are mostly made by those scientists who are either working as individuals or in small groups, but not a part of the larger research team of the department.

The largest number of respondents who had made drastic shifts are from Delhi (46%). But it is to be noted that most of the respondents of the Delhi department were doing research in Theoretical physics. The explanation for such shifts according to the respondents is the result of active and meaningful interaction with seniors and juniors, that allowed for curiosity, questioning, and exchange of knowledge. The respondents however feel that such shifts are possible only because they work on theoretical problems which require only the help of computers, that too not always. In contrast only 22% of Madras B (the other Theoretical physics group) respondents have made drastic shifts, a major percentage (56%) of them have made related shifts.

The other significant group that has made drastic shifts belong to Baroda Y. It is essential to note that they were primarily experimentalists. The reason for their shift is situational. Initially there were only two professors in this department who had built their laboratories - one working in Ultrasonics and the other in Luminiscence. The younger faculty were in a way divided into research teams under the two professors. Unfortunately, the professor working in Ultrasonics, fell ill and the laboratory did not get much attention and the

team was not sufficiently active. Hence those who were initially working in Ultrasonics shifted to the laboratory of the other professor and joined his team. They opined that this was basically due to the limited facilities available in their institution. However, they had to spend some time learning the new field and had to go through an unproductive period too.

Apart from these groups 15% of our respondents mentioned that they have switched over to more specific or specialised problems within their original areas of interest. Thus their shifts refer to narrowing down of their research interests, sometimes in order to keep pace with frontier areas. Perhaps it is more fashionable to say that 'I work on Superconductivity' than to say 'I work in Condensed Matter physics'.

5.3.2 Extent of Shifts in Theoretical and Experimental Physics

During the course of our discussion, we pointed out that some respondents felt that it is near to impossible to make and remake laboratories which in a way constrains the research interests of experimentalists. Table 5.5 furnishes details on the strength and validity of such an argument. There were more experimentalists in our sample - 48% than theoretical physicists (43%) who had changed their research interests. However, when we look at the number of those who have made shifts of any kind, we observe that while 76% of the theoretical physicists have either modified or diversified their interests, only 62% of the

TABLE 5.5

COMPARATIVE ANALYSIS OF EXTENT OF SHIFTS

UNIVERSITIES		NO RESEARCH	THEORETICAL		EXPERIMENTAL		TOTAL NO. OF RESPONDENTS
			TOTAL	NUMBER SHIFTED	TOTAL	NUMBER SHIFTED	
BARODA	(X)	4	2	1(50%)	8	3(38%)	14
	(Y)	3	1	0	8	6(75%)	12
MADRAS	(A)	0	4	0	9	7(78%)	13
	(B)	0	9	9(100%)	0	0	9
	(C)	0	3	2(67%)	3	3(100%)	6
BANGALORE		0	2	2(100%)	7	3(43%)	9
DELHI		1	16	14(87%)	7	4(57%)	24
TOTAL		8	37	28	42	26	87
		9%	43%	(76%)	48%	(62%)	

experimentalists have done so. The popular belief that experimentalists have an in-built constraint to switch over fields does not therefore fully apply in our case. Of the six departments that have experimentalists, about 75% of total working in experimental areas in three departments have ventured into newer areas. How then, can this phenomenon be explained?

The three departments with high rates of switch over among experimentalists are Baroda Y Madras A and C. The reason for the shift with respect to Baroda Y has already been explained. In the case of Madras A, referring to details in Table 5.4, we find that respondents had made either related shifts or had switched over to more specialised areas, only 15% had made drastic shifts. This can be explained as follows: This department in the initial years was developed to build an active research team in the above mentioned research areas and hence the laboratories were equipped accordingly. During the second phase of recruitment and expansion of the department, several candidates who had done no work in Crystallography or Biophysics were recruited. The new recruits therefore had to modify their interests both in accordance with the available facilities and in order to fit in with the group. In the case of Madras C details of Table 5.4 do not show any one of them having made drastic shifts. Hence the 100% shift of the experimentalists of this department as shown in Table 5.5 can be understood as shifts in terms of sharper focus to their research areas. The same can be

said about the Bangalore respondents and to some extent of Baroda X too. The Delhi experimentalists, while in concurrence with the view of difficulty to build laboratories, also mentioned that change towards 'hot' areas is inevitable, whatever the price one has to pay.

Looking at the theoretical physicists, one observes a high rate of diversification and modification of research interests - above 60%. One wonders whether this is a general tendency among those working on problems in theoretical physics. The explanation for this high percentage among Delhi respondents has already been discussed. The equally high percentage in Madras B and Bangalore constitutes interesting comparison. Madras B has no particular area of interest for the whole group and hence individual faculty have the freedom to work on problems of their interest in any area of theoretical physics. There is no rigidity of specialisations expected of them.

Conversely it may be mentioned that Bangalore has priority research areas for the department with clear long term goals in Molecular Biophysics. As discussed in detail in the earlier chapter, recruitment of faculty is always in terms of this perspective. Shifts therefore for them must have been a necessary requirement. Cross checking with data given in Table 5.4 we find that none of them have made drastic shifts.

5.3.3 Factors Affecting Shift in Research Interests

Before plunging into a discussion on the factors that have significant influence on change of research interests,, certain clarifications are in order. No classification is retained or maintained between theoretical physicists and experimental physicists for purposes of the present analysis. The factors as identified by the respondents are listed below.

1. Out of own interest
2. Frontier area
3. Area unexplored
4. Greater value for applied research.
5. Area was competitive and had enormous commercial value
6. Shifted to an area where less money was required
7. Area was heavily funded
8. Identified problems while teaching a course
9. Picked up problems while abroad on short trips
10. To develop a diversified group, encouraged students to work on diverse problems.
11. Research students showed interest to work in various areas
12. Due to interaction with colleagues who were working on different problems
13. Developed interest in instrumentation, as some faculty were too possessive about their equipment.
14. In order to fit in with the research interests of the department and work according to its needs.

15. To do research in accordance with the departmental facilities available and accessible (primarily experimental) implying lack of facilities for one's own area of interest.

The above list is not an exhaustive one but it certainly gives some idea about the academic and quasi academic factors that play a role in directing one's research. They can be broadly classified as (i) individual or personal factors and (ii) institutional or departmental factors. The relevance of these factors to the respondents of the seven departments are shown in Table 5.6.

Of the fifteen factors, four seem to have greater significance to respondents in all the departments. They are as follows:

1. Out of own interest - 19%
2. Frontier area - 15%
3. Area unexplored - 13%
4. To fit in with the research interests of the department and contribute according to its needs - 13%

The first reason i.e. 'out of own interest' is not very specific or clear. It implies that interests may be developed as a result of scanning journals, attending lectures, seminars and exposure to newer knowledge in related ways. However, one can

TABLE 5.6

FACTORS AFFECTING SHIFT IN RESEARCH INTEREST

UNIVERSITIES		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15*	TOTAL
BARODA	(X)	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	4
	(Y)	1	-	1	3	-	-	-	-	-	-	-	-	-	1	-	6
MADRAS	(A)	2	1	-	-	1	-	-	-	-	-	-	-	-	1	2	7
	(B)	3	1	2	-	-	-	-	-	-	-	-	1	-	1	1	9
	(C)	1	1	-	-	-	-	-	-	1	-	-	-	1	1	-	5
BANGALORE		1	-	1	-	-	-	-	-	-	1	-	-	-	2	-	5
DELHI		1	3	3	1	-	1	1	1	1	-	1	3	-	1	1	18
TOTAL		10	8	7	4	1	1	1	1	2	1	1	4	1	7	5	54
		(18%)	(15%)	(13%)	(7%)	(2%)	(2%)	(2%)	(2%)	(4%)	(2%)	(2%)	(7%)	(2%)	(13%)	(9%)	(100%)

*THESE NUMBERS CORRESPOND TO THE FACTORS LISTED UNDER THIS SECTION IN THE SAME ORDER.

assume that these respondents have accessibility and exposure to such material either provided for by the institution where working, or out of curiosity and initiative to look for them.

Much related to the above factor, 15% physicists have changed their research interests with the shift in frontier areas, and 13% cited "area unexplored" as reason for their shift. It is understood that contribution to an unexplored and new area is much easier than a saturated one. The opportunities for exchange and recognition is also felt to be higher. Besides, 'hot areas' also attract more funds. Above all, it is fashionable too to work in them. In contrast, some opined that locating genuine problems becomes difficult in a saturated area and hence more difficult to contribute meaningfully to it. All the above reasons are 'individual oriented', as the change is out of the scientists' own volition.

In contrast the last factor mentioned above, refers to a change of research interest for a larger cause - to contribute to the research goals of the department according to one's capacity. We have shown in the earlier sections of how recruitment in some departments is directed towards hiring scientists with proficiency in certain fields or methods. In some others recruitment of faculty with diverse specialisations has been accidental or situational. However, all these faculty members change their research interests soon after entering the department either due to requirement or owing to lack of

facilities to pursue their own interests. These scientists, it should be noted, are primarily experimentalists, for theoretical physicists need very little infrastructure and therefore can also pursue their own interest apart from contributing to the department, if necessary.

Three other factors that have some relevance for the shifts in research areas are:

4. Greater value for applied research - 7%

12. Due to interaction with colleagues working on different problems - 7%

9. Picked up problems while abroad on short trips - 4%

Data analysis in Table 5.6 shows that shifts made for application value are more prevalent among the Baroda respondents more specifically Baroda Y. They have used their techniques in the study of luminiscence to study quality control in the drug industry, in the study of polymers etc. The location of the department in a state and region well known for its textile and chemical industries may have influenced priority to such problems.

The other two factors are similar in some ways but different too. They both relate to shifts due to interaction - one internal interaction with colleagues, and the other due to external interaction. We find greater occurrence of the former among scientists of Madras B which is a theoretical physics department and the latter among scientists of Madras C and Bangalore.

Though international mobility is pronounced in atleast five of the seven departments, only 4% have picked up problems this way. This seems a remarkably low percentage in comparison to the general impression of Indian scientists picking up research problems during short trips abroad. There is some difference between Madras C and Delhi. As scientists of Madras C concentrate on one specialised area - Nuclear physics and hence such shifts have a significant impact on team work, while for the Delhi respondents it tends to be largely an individual and independent choice and has little impact on the research activity of the department as a whole. Besides, factors such as science policy of the country, the specific policies and programmes of the funding agencies in identifying Thrust Areas of research also affect choice of research problems. However, these do not seem to have had much relevance to our scientists as evident from Table 5.6.

SECTION II

5.4 RESEARCH PRODUCTIVITY

The nature of modern science is highly specialised and scientists are located all over the world that the transfer of scientific information cannot depend entirely on the movement of scientists. The diffusion of scientific information through specialised research journals has become the most prominent mode of communication. This system of publications in journals has

been made rigorous and objective through measures such as the refereeing system.

The following sections analyse the research productivity of the scientists of our study. We begin with a broad classification of research papers with reference to their year and source of publication namely Home journals, Indian journals, Foreign journals and Conference proceedings.

5.4.1 Research Papers : Classification Based on Source and Year of Publication

Earlier studies on research productivity were focused on problems like communication patterns among scientists, the social organisation of the scientific community, diffusion of ideas among scientists or the growth of knowledge in a research area. Their object of enquiry was always the history of research productivity, authorship patterns and citation analysis of individual scientists belonging to a research area or discipline. In contrast, we wish to attempt an analysis of the birth, growth and decline of physics departments by studying the research productivity of scientists within the context of their institutional/departmental affiliation. As the selected seven departments for this study are in different stages of growth, the problem of comparability came to the fore.

They have been instituted at different points of time from 1942 to 1972. Thus they have been at different stages of growth

when the study was conducted. Two of our seven departments were established by 1950, there were three departments by 1960, six out of the seven had been established by 1970, but all the seven departments had become full-fledged and independent by 1980. Our field work was conducted in 86-87 and hence data on research productivity is upto that time. We decided to make 1970 as the cut off year as it covers to some extent all the seven departments in both time periods 49-70 and 71-86.

The first striking feature of data in Table 5.7, is the conspicuous absence of publication in home journals by the Madras and Bangalore respondents. This is simply due to the non-existence of journals at that time in these universities. Much later, Madras university did bring out a journal of a general nature. The Indian Institute of Science too initiated a number of research journals primarily under the auspices of the Indian Academy of Sciences. Gradually they have gained popularity.

When we look at the second category - publication in other Indian journals, the percentage of Indian publications is consistently low in all departments except for the respondents of Baroda X. 64% of the total publications of these departments have been in other Indian journals apart from their home journal. From the detailed list of publications provided by the respondents, we find that they are of a mixed nature. They do include some research papers, but also deal with such aspects as innovations and experience in teaching, problems of general

TABLE 5.7

DISTRIBUTION OF RESEARCH PAPERS BASED ON SOURCE OF PUBLICATIONS
DURING 1949 AND 1970

UNIVERSITIES	HOME.JRL.	INDIAN JRL.	FOREIGN JRL.	CONFERENCE PROC.	TOTAL
BARODA (X)	7(23%)	19(64%)	4(13%)	0	30
(Y)	1(8%)	3(21%)	10(71%)	0	14
MADRAS (A)	0	20(21%)	64(68%)	10(11%)	94
(B)	0	2(4%)	44(80%)	9(16%)	55
(C)	0	1(3%)	26(66%)	12(31%)	39
BANGALORE*	0	13(15%)	63(72%)	12(13%)	88
DELHI**	9(2%)	60(16%)	269(70%)	49(12%)	387

*One out of the nine respondents did not provide a list of publications.

**18 out of 24 respondents of this department evaded giving a detailed list of their publications. Hence the data analysis is only for 6 respondents and is therefore incomplete.

science etc. This factor could be better understood if some historical details can be recalled.

Baroda X unlike even Baroda Y or the other departments of the study did not have a strong research tradition from its inception. Without defined research goals or a leader, their publications have been diffuse. Furthermore, being a teaching department, the emphasis laid on their publications has also been related to problems in teaching, revision of syllabi etc.

For the remaining six departments the highest percentage of publications has been in foreign journals. In the opinion of the respondents, recognition within their department, i.e., even from their immediate colleagues can be obtained only when one has publications in international journals. This, they say, is more important in the initial years of one's career. Publications in Indian journals after a few foreign publications seem to be acceptable. Publishing in foreign journals according to them is also important when they are evaluated for promotions or when they seek jobs in other institutions. Another explanation to account for such behaviour rests in the educational background of the respondents of these departments.

It may be recalled that a number of respondents from these departments have been abroad either for their doctorate degree or for post-doctoral work. Their publications while abroad have been in foreign journals. Having been exposed to the western scientific world and gaining confidence, they continue to send

their research work for publication in foreign journals even after return. In this context, the remark of a senior respondent of Bangalore makes interesting reading. He said that they send their doctorate students specifically abroad at least for a couple of years, as it provides the necessary exposure and also gives them the confidence to work independently on return (if they do).

The last category of Table 5.7 refers to publications in conference proceedings. Both the departments of Baroda do not have even a single publication of this kind. This observation is in line with the earlier observation made with respect to their high percentage of publications in Indian journals. However it should be noted that Baroda Y was gradually being established only in the late 60's and hence the fruits of their research work would be more evident in the next time period 71-86.

On the other hand, we find a significant percentage, i.e., about 31% of the publications of physicists of Madras C have been in conference proceedings. We find that these publications are primarily of the two senior faculty members of the department. One of them is a professor of theoretical Nuclear Physics, while the other is an experimentalist. It may be noted that Nuclear physics was considered a frontier area during the 50's and 60's and hence was at its peak in India then. Drawing financial support from the government of India, active scientists in this

area must have had many more opportunities to get together in comparison to scientists working in other specialisations.

The data in Table 5.8 highlights the uniform increase in the total number of papers published in all the departments. In comparison to the earlier period, i.e., 49-70, some changes however are evident. Looking first at those aspects with no changes, we find that the percentage of publication in foreign journals continue to be higher than the rest, signifying no change in the priority of journals. Even Baroda X has increased its foreign publications significantly from 13% to 36%.

Nevertheless, Baroda X and Madras C are exceptions to the pattern of priority. The largest number of publications of Baroda X is in Indian journals and of Madras C is in conference proceedings. The explanation for such an occurrence has already been given to some extent earlier. With reference to Madras C, it was found that 65% of the publications listed under conference proceedings are those of a single professor of the department primarily an experimentalist. Referring to his career profile and research interests, we find that his interests in conference presentation range from school physics to instrumentations for his research requirements. Such factors as individual differences greatly bias inferences when statistical data for departments as a whole are considered for drawing generalisations.

TABLE 5.8

DISTRIBUTION OF RESEARCH PAPERS BASED ON SOURCE OF PUBLICATIONS DURING 1971 AND 1986

UNIVERSITIES	HOME.JRL.	INDIAN JRL.	FOREIGN JRL.	CONFERENCE PROC.	TOTAL
BARODA (X)	2(2%)	62(48%)	47(36%)	18(14%)	129
(Y)	4(5%)	17(22%)	50(65%)	6(8%)	77
MADRAS (A)	9(2%)	71(17%)	269(66%)	63(15%)	412
(B)	0	22(15%)	103(72%)	18(13%)	143
(C)	7(2%)	25(8%)	129(41%)	153(49%)	314
BANGALORE*	3(1%)	56(11%)	403(78%)	56(10%)	518
DELHI**	3(2%)	13(8%)	127(79%)	18(11%)	161
TOTAL	28	266	1128	332	1754

*One out of the nine respondents did not provide a list of publication.

**18 out of the 24 respondents of this department evaded giving a detailed list of their publications. Hence data analysis is only that of 6 respondents and is therefore incomplete.

The next observation refers to the consistent low percentage of publications in home journals. Though this percentage is reduced even in the case of Baroda respondents, we find that their publications in Indian journals have gone up and are mostly in journals of other Indian universities. This change of emphasis could probably be due to a technical reason. Universities do go through several phases of development and at times are unable to bring out issues of their journals regularly. The Baroda respondents, we find, have published in other university journals, which may have been due to the irregular issues of their home journals. If this correlation is acceptable, a decrease in the percentage of publications in home journal has no serious implication for the category of Indian journals as whole.

In contrast, Madras B has no home journal publication, but has 15% publications in other Indian journals. Their publications in Indian journals are on general science and reflect enthusiasm for publishing popular articles on science.

With reference to the last category, Baroda X and Y show increased participation in conferences, when compared to the earlier period. There is however no significant change with respect to the other departments. To sum up, considering both the time periods, the following inferences may be drawn :

(i) There is a predominant trend to publish papers in foreign journals which seems the first priority

(ii) There is a concommitant decrease in the tendency to publish in home journals, whatever the nature of the paper

(iii) Publications in other Indian journals is significant and have increased over the two time periods

(iv) There is also a trend towards increased participation in conferences as differences in conference proceedings shown in Tables 5.7 and 5.8.

5.4.2 Research Papers and Publication Outlets

For a detailed understanding of publication preferences it is essential that the publication outlets or the countries of origin of the journals be taken into consideration and the time span and years covered be further broken down. The purpose of this exercise is to gain some insight into the interaction and 'identity seeking' pattern of the respondents through their publications.

The key journals of any discipline or specialisation shift along with the 'centres of learning'. But the journals of an earlier centre do not die immediately; they may suffer in the quality of production. Thus an analysis of the publication outlets of our respondents would reveal the extent to which our respondents try to compete and are successful in international science.

However, certain details have to be clarified before one starts with the analysis. Unlike the earlier classification, all Indian publications here are grouped together with no distinction

between home journals and other Indian journals as our purpose here is to look at publications in journals in relation to the status of science of the respective countries from which they are published.

Foreign publications have been categorised mainly under three countries of the world - U.K., U.S.A. and Germany as these represent the current and earlier centres of learning in the recent past. The remaining foreign publications are classified under 'Other Countries'. Mention of the countries will however be made wherever relevant. As for the time periods, the years between 51 and 85 have been divided into five categories - each a seven year period, i.e., 51-57, 58-64, 65-71, 72-78 and 79-85. Effectively the earliest publication of our respondents dates back to 1951. Similarly the latest year at the time of study was 1985. Our classification into seven year periods is primarily to understand productivity patterns with respect to the different stages of growth of the seven departments.

The publications of the respondents in these periods were analysed with respect to their outlets for each department independently. It was found that two time-periods, 72-78 and 79-85 have been the most productive for all the departments, except Delhi. The years 65-71 is seen as the active phase for this department. This pattern of high productivity or low productivity in research to some extent depicts the rise and decline of departments. Taking note of such a trend the detailed

break-up of publication outlets are being discussed only for the two active periods 72-78 and 79-85 for the seven departments.

The years 65-71 is active for Delhi, but a discussion of this period will not be undertaken for the following reasons. The low productivity contribution of Delhi has been mentioned even earlier. 75% of the respondents (i.e. 18 out of 24) did not provide their publication list and hence an analysis of the productivity patterns of this department is incomplete. It would probably be of some interest to narrate here some field work experience.

It was learnt that in one of the 'Coffee-House sessions' of the faculty concerned, the relevance and entry of an outsider to conduct such a study was discussed. Those who were to be interviewed were curious to know some details about the questions that were asked, nature of information parted, whether one can give 'this outsider' a list of research publications. Opinion, it is said, varied. Some felt that it was no cause for great danger as it is only a record of the papers already published, while others felt that a publication list is a personal property related to one's career and hence should not be available for public circulation and scrutiny.

Such an opinion apparently prevailed strongly on those members who were interviewed later. They gave some excuse and evaded the issue of providing a publication list. This to some extent accounts for the incomplete analysis of the productivity

pattern of the Delhi respondents. As such, it is difficult to make any inference even regarding the active phase of this department which appears to be 65-71.

Before proceeding to discuss the details in Table 5.9 some clarifications are in order. If one compares the statistics given in Tables 5.7 and 5.8 with those of 5.9, some discrepancies may be noted. In the earlier section, the number of publications of each and every faculty member was taken into account along with their outlets. However, it was noted that research publications often have been co-authored by faculty members of the same department. Beginning from Table 5.9, such papers have been counted only once and henceforth the distribution of research publications will be considered for each department as a whole.

Though it was clear that 72-78 was one of the productive phases of the departments, Table 5.9 shows that even amongst them, Madras A has been the most productive. It has 34% of the total publications for this period and Bangalore scientists follow next with 22% of the total research output.

Looking then at the countries of origin of the journal publications, the maximum contribution falls in the group of other countries - consisting of 38% of the total publications. Publications in Indian journals follow next with 27%. However, this high percentage of Indian publications does not in anyway explain the nature of the national spirit of the respondents. it

TABLE 5.9

RESEARCH PAPERS AND PUBLICATION OUTLETS: 72-78

UNIVERSITIES	INDIA	U.K.	U.S.A.	GERMANY	OTHER COUNTRIES*	TOTAL
BARODA (X)	16(14%)	2(7%)	-	1(4%)	8(5%)	27(6%)
(Y)	12(10%)	3(10%)	-	5(21%)	10(6%)	30(7%)
MADRAS (A)	38(32%)	7(24%)	35(36%)	5(21%)	65(40%)	150(34%)
(B)	5(4%)	3(10%)	24(24%)	-	15(9%)	47(11%)
(C)	15(13%)	7(24%)	7(7%)	4(17%)	12(7%)	45(10%)
BANGALORE	28(23%)	5(18%)	21(21%)	2(8%)	38(23%)	94(22%)
DELHI	5(4%)	2(7%)	12(12%)	7(29%)	16(10%)	42(10%)
TOTAL	119 (27%)	29 (7%)	99 (23%)	24 (5%)	164 (38%)	435 (100%)

*Includes: Australia, Belgium, Canada, Denmark, Holland, Italy, Ireland, Japan, Hungary, Switzerland and USSR.

needs to be probed, whether the respondents send their research papers to promote Indian journals and to generate consciousness among the scientific community or they publish in them because foreign outlets are not possible for such material. While both reasons seem plausible, the latter seems more probable.

Considering foreign publications with reference to journals from a single country, we find that 23% of the research papers have been published in American journals, UK following far behind with 6% and German journals carrying only 5% of the research publications of our respondents. The priorities of our respondents clearly reflect their efforts to gain identitity among the scientists of the active centres. It is well acknowledged that the US is an active centre in terms of research in modern sciences.

If the above relation between key journals and recognised active centres of learning is acceptable, then certain findings shown in Table 5.9 are quite intriguing. It is understood that the key journals of a particular period are published from the active centres to which researchers all over the world subscribe. Besides, they also aim to publish in them for two main reasons (i) in order to reach out to the maximum number of scientists working in the area as these journals generally have a large circulation and (ii) in order to gain recognition for their work from fellow scientists.

It is intriguing to note that a high proportion (38%) of publications of the physicists in our universe of enquiry is in the journals published from 'other countries' a category in which North Holland, Denmark and a few other European countries are prominent. However, the mystery is resolved when we look at the nationality of these editors. Mostly they belong to USA and UK and in some cases even to other countries. In this context it is then difficult to understand as to how several journals are published from North Holland and nearby countries which are not really well known for science research. One explanation for this is given by some physicists. It is the existence of some very good publishing houses in these countries. Some of them (Springer-Verlag for example), have earned such repute that libraries straightaway order for their publications. It is also understood that these publishing houses have expanded into journal publications. Of late they even get some publications (North Holland) printed in India as the printing cost is relatively cheaper here.

Another explanation, given by some other physicists, is an academic one. The eminent physicist Niels Bohr in the middle of this century had his laboratory in Denmark. Some of the journals may have been started during his time and gained status and popularity because of his contribution and those of the scientists who worked with him. It may be no surprise that such journals continue to be the leading ones changing their editorial

board from time to time in order to include the active scientists and also to maintain the high status they have achieved.

Analysis in table 5.10 shows that in comparison to the earlier period, and also in comparison to other departments Bangalore has published maximum number of papers. Madras A which had the highest in the earlier period shows a decline during this period. It therefore indicates a period of low productivity for Madras A. Madras A identified by the UGC as a Centre of Advanced Study in the early 60's was de-recognised in the mid 70's due to lack of research activity and productivity.

Considering the outlets, we find that research papers under 'Other Countries' continue to be higher with 31% of the total publications. Unlike the earlier period 72-78, publications in American journals ranks second with 28% and those in Indian journals constitute 22% of the total publications. However, there are departmental variations. While for the Bangalore respondents, American and British journals are the main outlets, for the respondents of Madras A, Indian journals seem to be the priority. This shift in priorities of the journals was explained by the head of the department of Madras A, in terms of two factors (i) the migration of a major part of the research group trained from A of Madras to Bangalore. This had suddenly brought down the productivity rate as a whole. (ii) Filling up of vacancies so created with faculty from specialisations other than

TABLE 5.10

RESEARCH PAPERS AND PUBLICATION OUTLETS:79-85

UNIVERSITIES	INDIA	U.K.	U.S.A.	GERMANY	OTHER COUNTRIES*	TOTAL
BARODA (X)	23(17%)	3(3%)	2(1%)	4(13%)	6(3%)	38(6%)
(Y)	2(1%)	5(6%)	9(5%)	6(19%)	6(3%)	28(4%)
MADRAS (A)	42(30%)	5(6%)	38(21%)	7(23%)	57(28%)	149(24%)
(B)	17(12%)	16(18%)	12(7%)	1(3%)	5(3%)	51(8%)
(C)	18(13%)	17(20%)	17(9%)	4(13%)	13(7%)	69(11%)
BANGALORE	29(21%)	32(37%)	73(41%)	5(16%)	93(47%)	232(37%)
DELHI	8(6%)	9(10%)	28(16%)	4(13%)	17(9%)	66(10%)
TOTAL	139(22%)	87(14%)	179(28%)	31(5%)	197(31%)	633

*Includes: Australia, Belgium, Canada, Denmark, Holland, Hungary, Italy, Japan, Switzerland and USSR.

Crystallography and Biophysics has given rise to a situation of low productivity due to the lack of facilities in areas of their research interests.

The consistent low productivity in the remaining departments can be understood in the following way. If one considers the average number of publications from each department, then we have the following figures, for the period 79-85.

University	Deptts.	Average publications (for seven years)
Baroda	(X)	2.7
	(Y)	2.3
Madras	(A)	11.4
	(B)	5.6
	(C)	11.5
Bangalore		25.7
Delhi		11.0

Accordingly, we find that only the two departments of Baroda and Madras B have comparatively low productivity. Needless to say, Baroda X has greater teaching responsibility. Besides, the lack of a continuity in active research groups in the department may to some amount account for its low productivity. The respondents of Madras B claim that theoretical work as such is difficult and does not promote high productivity.

It is probably appropriate here to mention that both the leading departments of the two time periods, i.e., Madras A and Bangalore, are predominantly experimental in their research work. C of Madras also has a high average and has a mix of both

experimental physicists and theoretical physicists. How then do they manage to have high productivity? It was learnt that this department Madras C has regular collaboration with a laboratory in Sweden, which is visited by almost all members of the department faculty and doctoral students regularly. Baroda Y did have some dynamic leaders, who were primarily interested in experimental work. However, with very few faculty members interested in 'active research' and few research students, the departmental research work is relatively low and slow. The data on Delhi is limited for reasons explained earlier.

5.4.3 Publication Outlets and Specific Journals

In the view of our respondents and other physicists, all journals published from same country, for example, U.S.A. cannot be considered equally of high quality. For, research is carried on at various levels of quality in a single country, at times even within a single institution at a particular point in time. Hence our attempt here to analyse the distribution of research papers according to the journals in which they have been published even within a country, seems a necessary exercise.

The analysis in Tables 5.9 and 5.10 shows that publications in journals classified under 'Other Countries' were highest for both the time periods. The second highest number was in Indian journals for 72-78 but American journals for 79-85. In the ensuing discussion, we would look into the journal break-up for 'other countries' for 72-78 and for American journals for 79-85.

To begin with, the journals of other countries were first listed according to their country of origin. We had 28 journals in all. Their distribution according to the country of origin for 72-78 is as follows:

Country	No. of Journals
CANADA	2
DENMARK	3
HOLLAND	16
POLAND	1
ITALY	3
JAPAN	2
USSR	1
TOTAL	28

As shown in Table 5.9, publications in these journals constitute 38% of the total publications for the seven years 72-78. Though the maximum number of journals preferred, are published from Holland, our analysis shows that the maximum papers published in a single journal is Acta Crystallographica published from Denmark constituting 39% of the publications under the category of other countries.

We have a total of 164 papers in 28 journals for this period. But only a part of this analysis is shown in Table

5.11. We have included only those journals that had five or more publications and hence only eleven journals out of the 28 are listed. This represents 84% of the total publications under this category of other countries for 72-78 with 138 publications.

As seen in the Table 5.11, more than one-third of the total publications are in a single journal Acta Crystallographica. It is preferred largely by the respondents of Madras A and Bangalore and to some extent Delhi where the journal has relevence to the research area pursued, namely Crystallography and/or Biophysics.

The next highest number of publications, though, with a big difference, is in two journals (a) Journal of Crystal Growth and (b) Nuovo Cimento. While former again relates to the same area Crystallography, we find that the respondents of Madras A and Bangalore do not publish in this journal. However, it is preferred by physicists of Baroda X and Delhi. The other Italian journal Nuovo Cimento is largely a journal of theoretical physics and hence the maximum publications in it are by the physicists of Madras B.

Moving then to publication outlet and journal preference with reference to U.S.A. for the period 79-85, we have the following data. The journals when listed alphabetically numbered 39 with about 179 publications. However, as done for the earlier period, we have included in Table 5.12 only those key journals that had five or more publications. These then amount to 13 journals and 143 publications, constituting 79% of the total.

TABLE 5.11

PUBLICATION OUTLETS AND JOURNAL CATEGORISATION: OTHER COUNTRIES (72-78)

COUNTRIES/JOURNALS	BARODA X	BARODA Y	MADRAS A	MADRAS B	MADRAS C	BANGALORE	DELHI	TOTAL	PERCENTAGE OF TOTAL
DENMARK									
Acta Crystallographica	0	2	44	0	0	11	7	64	39%
Internat. Jl. of Peptide & Protein Research	0	0	3	0	0	3	0	6	4%
HOLLAND									
Bio-Chem, Bio-Phys. Acta	0	0	3	0	0	5	0	8	5%
Carbohydrate Research	0	0	2	0	0	7	0	9	5%
Jl. of Crystal Growth	7	0	0	0	0	0	3	10	6%
FEBS Letters	0	0	0	0	0	6	0	6	4%
Nuclear Physics 'A'	0	2	0	0	5	0	1	8	5%
Physics Letters 'B'	0	3	0	0	2	0	0	5	3%
POLAND									
Acta Phys. Polon	0	0	7	0	0	0	0	7	4%
ITALY									
Crystal Structure Communication	0	0	3	0	0	2	0	5	3%
Nuovo Cimento	0	0	0	8	1	0	1	10	6%
Total	7	7	62	8	8	34	12	138	84%

It is interesting to note from Table 5.12 that there is a sharp difference across departments. We find that Baroda X does not have a single publication in any of these 13 American journals for the period 79-85. It should however be noted that these journals are a good mix of both theoretical and experimental research oriented physics. The highest productivity in terms of publication in these American journals is of the physicists of Bangalore. The largest number of publications in terms of a single journal is Bio-Polymers. It is largely a contribution again of Bangalore physicists. The second most popular journals are (a) Bio-physics, Bio-Chem Research Communication and (b) Physical Review 'C'. They are largely patronised by the respondents of Bangalore and Madras C matching significantly with their research interests.

Looking at these outlets departmentwise, Madras A seems to be the second highly productive department after Bangalore. though, with a big difference. However, the major contribution of the physicists of Madras A is in the International Journal for Quantum Chemistry with Bio-Polymers closely following as the second. It should be acknowledged that though Madras A and Bangalore to some extent, work in the same area of research specialisations, it is highly probable that the problems chosen are of different nature, which affect the kinds of journals sought for publication. Further, though Madras A in its initial years of expansion, concentrated on research in a specific area,

TABLE 5.12

PUBLICATION OUTLETS AND JOURNAL CATEGORISATION: USA (79-85)

JOURNALS	BARODA X	BARODA Y	MADRAS A	MADRAS B	MADRAS C	BANGALORE	DELHI	TOTAL	PERCENTAGE
Jl. of Molecular Biology	0	0	2	0	0	7	0	9	5%
Bio-chemistry	0	0	1	0	0	6	0	7	4%
Jl. of Biological Chemistry	0	0	2	0	0	4	0	6	3%
Jl. of American Chemical Society	0	0	1	0	0	7	0	8	4%
Bio-physics, Bio-chem. Res. communication	0	0	1	0	0	15	0	16	9%
Bio-polymers	0	0	6	0	0	20	0	26	15%
Internat. Jl. of Quantum Chemistry	0	0	9	0	0	2	0	11	6%
Physiological Chem. & Physics	0	0	5	0	0	0	0	5	3%
Jl. of Phys. Chem. of Solids	0	0	2	0	2	0	1	5	3%
Jl. of Mathematical Physics	0	0	0	2	0	0	11	13	7%
Physical Review 'D'	0	0	0	6	0	0	9	15	8%
Physical Review 'C'	0	5	0	2	7	0	2	16	9%
Solid State Comm.	0	0	0	0	5	0	1	6	3%
Total	0	5	29	10	14	61	24	143	79%

we have discussed in the earlier chapters about the nature of later recruitment of faculty with different interests. This to some extent accounts for the diffused nature of publications by the respondents of Madras A.

The greater preference for journals categorised under'Other Countries' explains to some extent (Tables 5.9 and 5.10) fewer publications in American journals by scientists of some departments. While the U.S. has been acknowledged as a 'Centre of Learning' for the present times, there are several research specialisations even within a discipline - physics - which are active in some countries of the continent which do bring out their own journals. For the Indian scientist the primary objective is to publish his paper in the leading journal of his field; allegiance to a country of litle significance.

Data analysis in this chapter showed that research interests of respondents get shaped and modified in accordance with the overall research interests of the departments they join. Such shifts in research interests range from related to drastic. Shifts of the former kind have been mainly made by experimentalists of our study in order to make use of instruments or techniques available within departments. Drastic shifts have been made mainly by those respondents working on theoretical problems, which they opined is a result of interaction with other physicists. And such shifts in their opinion were possible

because they depended less on the infrastructural facilities in comparison to the experimentalists.

Discussion on research productivity in this chapter was mainly directed towards identifying the active phases of the departments' growth and with the aim of gaining insights on the recognition seeking process of respondents. Analysis showed that 1972-78 and 1979-85 have been the two active time periods in the departments. While Madras A had the highest productivity in the former period, Bangalore presented itself as the most active for 1979-85 with high research productivity. As for publication outlets, international journals published outside the country generally seemed to be preferred to Indian journals. However, choice of the journal varied with the research area and the nature of research problem and had no relation to the country of origin of these journals.

However, a detailed analysis of the interaction patterns of scientists within and outside their departments would enable us to understand better not only the active and inactive phases of a department's growth, but also the process of 'recognition seeking' (from the rest of the scientific community) practised by the scientists of our study. We undertake this exercise in the ensuing chapter.

CHAPTER VI

RESEARCH INTERACTION: INTERNAL AND EXTERNAL DYNAMICS

The analysis of research publications thus far, dealt with the nature of outlets available to science research in India. One could say that the concern was the end product, i.e., research output of Indian universities. This section aims to look into the dynamics of the research process - the nature of research collaboration involved - both internal and external. We begin by studying the authorship patterns of the papers published.

6.1 RESEARCH PUBLICATIONS AND NATURE OF AUTHORSHIP

To begin with, in Table 6.1, we have broadly classified the nature of authorship. The percentage of single-authored papers is compared with the percentage of co-authored papers across departments. However, some clarifications are essential before one proceeds with a discussion. It may be noted that the total number of papers in terms of the outlets provided in Tables 5.7 and 5.8 do not match with the total number of papers given in Table 6.1. The total number of papers here far outnumber the earlier ones. During the interview, the respondents were orally asked to give details regarding their publications - especially the total number of papers they have published and also the number of single authored, co-authored etc.. Later we requested

TABLE 6.1

RESEARCH PUBLICATIONS AND NATURE OF AUTHORSHIP

UNIVER-SITIES	PROFESSORS						READERS						LECTURERS*					
	TOTAL FAC.	TOTAL PUB.	SA	%	CA	%	TOTAL FAC.	TOTAL PUB	SA	%	CA	%	TOTAL FAC	TOTAL PUB	SA	%	CA	%
BARODA (X)	3	127	12	9	115	91	7	51	6	12	45	88	4	9	1	11	8	89
(Y)	3	104	19	18	85	82	8	28	3	11	25	89	1	8	2	25	6	75
MADRAS (A)	5	395	61	15	334	85	3	98	23	23	75	77	5	87	3	3	84	97
(B)	3	163	28	17	135	83	1	25	15	60	10	40	3	31	6	19	25	81
(C)	2	203	26	13	177	87	2	58	5	9	53	91	1	7	0	0	7	100
BANGALORE	6	572	50	9	522	91	3	56	3	5	53	95	0	0	0	0	0	0
DELHI	14	933	115	12	818	88	8	412	135	33	277	67	2	49	6	12	43	88
TOTAL	36	2497	311		2186		32	728	190		538		16	191	18		173	

SA - Single authored

CA - Co-authored

*R.A. not included as they are not permanent faculty members

them to provide a detailed list (printed) of their publications. As already mentioned, this was not done by several respondents especially from Delhi. Owing to this, a complete analysis with respect to publication outlets was not possible. However, the oral information facilitated analysis of authorship patterns and hence a greater number of papers in Table 6.1. There is one exception to this pattern in Madras C where the total number of publications in Tables 5.7 and 5.8 outnumber those in 6.1. This is due to some respondents providing a publication list with outlets clearly specified but without the details of authorship. With such enormous differences in data, a consistent analysis has become very difficult.

In spite of such discrepancies, Table 6.1 does give some idea on the nature of authorship. We find that the co-authored papers far outnumber the single authored ones both across departments and grades. We will examine publications of the former kind in some detail.

6.2 CO-AUTHORSHIP PATTERNS OF RESEARCH PUBLICATIONS

It is of interest to us to examine the nature of collaboration that our scientists engage in. Specifically, we will look into the extent to which they collaborate with their thesis supervisors, students and colleagues within their institution. This analysis would reflect on the nature of their

internal interaction. Details on co-authorship patterns are given in Table 6.2

On analysis, we find that fifty-one percent of the research collaboration across departments is with their students. Research activity, especially in the departments that are mainly experimental, depends largely on the work of research students. However, Baroda Y and Madras B are exceptions to this pattern.

The former is an exception in the sense that it shows distinctly greater collaboration with guides than with students. In the latter the number is evenly distributed among the 3 categories: with guides, with colleagues and with students. There are two reasons why collaboration with students is so low in the case of Baroda Y. Firstly, the recent phenomenon of Ph.D. boom in the department as a result of the introduction of the Merit Promotion Scheme, has forced faculty to register with their senior colleagues, who thus became thesis supervisors and research collaborators, to that extent.

Secondly, this department, located in the Faculty of Technology, gets few students for the research programme. The problem becomes further complicated because of the attitude of the faculty members towards applicants for research in the department. It is felt that boys would leave the programme once they get jobs and hence are not preferred. In case of girls, they feel that they may get married and quit the programme without completing it, although they feel that

TABLE 6.2

CO-AUTHORSHIP PATTERNS OF RESEARCH PUBLICATIONS

		FIGURES IN PERCENTAGES					
UNIVERSITIES	TOTAL CO-AUTHORED PAPERS	WITH GUIDE (i)	WITH STUDENTS (ii)	TOTAL (i)+(ii)	WITH COLLEAGUES (iii)	WITH OUTSIDERS (iv)	TOTAL (iii)+(iv)
BARODA (X)	126	29	61	90	9	1	10
(Y)	116	30	19	49	23	28	51
MADRAS (A)	493	18	47	65	12	23	35
(B)	170	29	28	57	29	14	43
(C)	237	17	43	60	14	26	40
BANGALORE	575	13	60	73	14	13	27
DELHI	371	8	66	74	20	6	26
TOTAL	2088	17	51	68	16	16	32

girls are more sincere and committed than boys. As a consequence JRF (Junior Research Fellowship) positions keep lying vacant in the department.

The story is different for Madras B. Two factors may explain the equal distribution of research publications among the first three categories: (i) it is a department of theoretical physics. As such, the kind of dependence on research students for experimental work does not exist here. (ii) There exists greater and more open interaction in this department, as they work in different research areas as seen earlier in the analysis of research interests of respondents.

It may be observed that there are some departments in which research collaboration is greater with outsiders than with the departmental colleagues. These are predominantly experimental in orientation. As pointed out in the earlier chapter, lack of infrastructural facilities to a large extent makes them seek the help of scientists from other institutions - mainly research institutions both within the country and outside. We would go into details of this external collaboration later. At this juncture we wish to supplement this information on internal collaboration with qualitative data on the informal interaction patterns of the respondents with their colleagues within the department. Such an exercise would probably enhance our understanding of the observations made - namely a very high degree of co-authored papers are with students and guides.

6.3 NATURE OF INTERNAL INTERACTION

The physicists in our study were asked to furnish details on the nature of academic (research) interaction with their colleagues within the department. More specifically, they were requested to give the probable number of departmental colleagues with whom they could meaningfully discuss research interests and also the actual number of colleagues with whom they share their research interests. Further, the nature of interaction they do have with this actual number was also probed into. Some kind of a classification was made based on this data which is shown in Table 6.3.

Some clarifications are essential before one proceeds to discuss details given in Table 6.3. The figures in the first column represent the number of respondents in each department who mentioned that there was a certain probability of interaction. Out of these, those who do actually interact with their colleagues is given in column 2. However, the actual nature of interaction with these colleagues varies. It may be limited to informal discussion, at times lead to serious dialogues about problem-solving and may also result in joint publications. We find that almost all the respondents have informal discussions, but do not have serious collaboration with their colleagues. This is represented in the decline in numbers when one reads the

TABLE 6.3

INTERNAL INTERACTION OF RESPONDENTS

UNIVERSITIES	PROBABILITY OF INTERACTION	ACTUAL INTERACTION	NATURE OF ACTUAL INTERACTION			TOTAL NO. OF RESPONDENTS IN EACH DEPTT.
			INFORMAL DISCUSSION	INTENSIVE DIALOGUES	JOINT PUBLICATION	
BARODA (X)	13	13	13	10	6	14
(Y)	8	8	7	4	3	12
MADRAS (A)	11	11	10	5	2	13
(B)	8	8	8	5	5	9
(C)	6	6	6	5	5	6
BANGALORE	5	5	5	5	4	9
DELHI	21	19	19	12	12	24
TOTAL	72	70	68	46	37	87

table across. We would now discuss the reactions and remarks of respondents department-wise.

Looking at Baroda X, we find that 13 out of the 14 respondents mentioned that they had informal discussions on research problems with colleagues in the department. However, collaboration and publication with them was much less as the decrease in figures show. One respondent remarked that they formed a group of about 10 members and worked with a team spirit. They did have free and open academic exchange with no individual, not even a professor dominating.

On the other hand with respect to Baroda Y, though we do find that 8 out of 12 respondents opined that there was scope for interacting with colleagues as their research interests are somewhat similar, yet we find that only 3 of them meaningfully exchange academic ideas that result in joint publications. Their remarks in this regard are worth noting. One factor that impedes interaction is the diversity in age structure of the members of the department. Table 6.4 shows that this department has younger professors (less than 45 years), but readers are much older. Active and enthusiastic faculty members probably have been given the chance (for one of them is the head), and seniority has played little role in promotions . Distance is maintained and interaction therefore is minimal and only functional.

A young professor had some other explanation in this regard. He was of the opinion that though there are several members in

the department who claim similar research interests, they do not have a genuine interest in research. Most of them did not possess a doctorate degree, but registered for one in order to benefit from the Merit Promotion scheme. Once the degree was obtained, a few papers were published which enabled their promotions, and then most of them lost interest in any further research. Thus in reality, the actual number of 'active researchers' is much less which then reduces the scope for any interaction. Another respondent remarked that there was no chance for interaction as members just visit the department when they have to take a class. As their teaching duties are not too demanding, it facilitates their early departure from the department all the more. This explanation can be accepted as non-availability of members significantly delayed our data collection. It was difficult to meet respondents even to take appointments. When one did manage, it was found that they always had other interests for which they were rushing from the department, for example, to watch a cricket match on the Television. Such a situation has led those interested in research to seek help from members of other departments whose intersts are in related areas.

On the other extreme, low interaction for one respondent was due to his personality. He always wants to be frank and fearless and in the bargain, he has been marginalised. However, he says that it has taught him the lesson that he should restrict

interaction with human beings in general. He has gone into too much philosophising and is generally regarded by the rest of the faculty as 'mentally off'. Besides, during the interview one gained the impression that he was also alienated from his family.

In Madras A, we find that but for two respondents, the rest did have scope for interaction with departmental colleagues. However, as Table 6.3 shows, the nature of interaction sharply declines from informal discussions to joint collaboration. We found only 2 out of the 11 respondents collaborating with their colleagues. It thus well relates to our observation on co-authorship patterns in the earlier part of this chapter, i.e. the publications are generally co-authored with students and minimally with colleagues. The explanation for such a situation in the respondents opinion is that each and every member of the department has developed his own area of 'micro-interest' and is independently working on it that collaboration is not only difficult, but almost impossible.

A senior professor however, expressed his anguish in this respect. One of his former students had been abroad for post-doctoral work and had joined the department as a faculty member on return. Since then, he stopped discussing any of his research ideas with his former thesis supervisor (a senior professor), now a colleague. The professor is of the opinion that this aspect of modern science, competitiveness, in a way kills efforts at group

building which is essential, given the complexity and interdisciplinary nature of the very same science and the scarcity of resources, particularly in the Indian context.

In contrast, one observes greatest internal interaction among the respondents of Madras B. A significant number of faculty members have co-authored publications with departmental colleagues. One respondent remarked that it was much easier to interact with junior faculty members than with seniors, not because they are unapproachable, but the age differences with seniors is vast. Table 6.4 shows that professors in this department are between 40 and 55 years of age and readers and lecturers are below 40 years. This could be due to long gaps between recruitment or due to policies in expansion.

Madras C functions as a group and though consisting of both theoretical and experimental nuclear physicists, interaction with colleagues is high and results in joint publications most often. It was learnt that collaboration with a colleague depends on the nature of problem undertaken at a point of time.

In the case of Bangalore, surprisingly, it is learnt that only 5 out of the total of 9 physicists interviewed mentioned probability of internal interaction in a meaningful way that could result in collaborative work. A couple of them, it was found were isolates due to some personality problems. Of the remaining two, one was a senior professor primarily working on theoretical problems and interacted (according to him) only when

TABLE 6.4

AGE STRUCTURE OF SAMPLE SIZE

AGE IN YEARS	BARODA						MADRAS											BANGALORE			DELHI			TOTAL			
	(X)			(Y)			(A)			(B)				(C)													
	P	R	L	P	R	L	P	R	L	P	R	L	RA	P	R	L	RA	P	R	L	P	R	L	P	R	L	RA
31-35	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	1	0	1	0	0	0	1	0	1	4	2
36-40	0	1	0	1	0	1	0	1	2	0	1	2	1	0	1	0	0	2	2	0	0	0	1	3	6	6	1
41-45	0	2	2	1	2	0	1	1	1	1	0	0	0	0	1	0	0	1	0	0	1	3	0	5	9	3	0
46-50	0	2	1	0	3	0	3	1	1	1	0	0	0	1	0	0	0	1	0	0	7	3	0	13	9	2	0
51-55	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	5	2	0	9	3	1	0
56-60	2	2	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	5	4	0	0
61+	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total	3	7	4	3	8	1	5	3	5	3	1	3	2	2	2	1	1	6	3	0	14	8	2	36	32	16	3
REAL SIZE	3	10	12	3	11	1	7	3	6	3	1	3	2	2	2	2	1	7	3	0	29	17	6	55	47	30	3
PERCENT RETIRING IN THE NEXT 10 YEARS (OF REAL SIZE).	24%			20%			6%			11%				14%				20%			15%			16%			

approached for any help by the remaining members of the department. He opined that he never initiated interaction both due to his age and nature of work. One striking feature of this department inferred from Table 6.4 is the policy of directed but gradual expansion. We find that there are young professors, but professors are found in different age groups. Such a feature helps not only easier socialisation of young faculty, but also guarantees regular inflow of young enthusiastic blood that maintains the standard of research activity of the department.

Delhi shows some interesting findings. While 21 out of the 24 respondents interviewed did mention probability of interaction with their colleagues, only 12 of them actually interact to the extent of collaborative research and joint publications. They however clarified that such collaboration was not a regular feature. It depends to a large extent on the problem chosen for research and the disposition of the colleague. It should be mentioned that almost all these physicists were theoreticians. There were some respondents who said that though they had done joint work with colleagues during their earlier years in the department, once students started registering under them for the doctorate degree, their research work has been restricted to joint work only with their students. This factor of joint work with students seems to be the central feature of research in universities. Comparatively, in the absence of research students

in research institutes, collaboration with colleagues is likely to be higher. However, this aspect needs looking into carefully.

Some personal and academic reasons have been cited for minimal internal interaction. Some respondents also remarked that since 'people are clammy about their research work, it is difficult to penetrate and interact'. However, a senior faculty member gave a systematic explanation to this phenomenon of low internal interaction. He says that it is largely due to two reasons: (a) There has been arbitrary and unplanned expansion of the department, recruiting faculty with diverse interests (b) Co-ordination therefore even among members with similar interests becomes difficult as the situation is highly competitive. He went on to add that this has reached unimaginable limits, for faculty at times are over possessive about their instruments; they do not allow others to use them even if the equipments are lying idle.

Such problems exist every where and it was found that the department that tries to get over such problems, comparatively performs much better. It may be of some interest to relate a similar experience narrated by a senior professor of the Bangalore department. Instruments are generally located in the laboratories of the various faculty members who are given charge. Once a research student needed to use an instrument that was lying in the laboratory of a new faculty member. When the student approached him, she was outright refused. The matter was taken

to the Chairman of the department. The problem was settled as follows. On inquiry, the faculty member expressed the view that careless use especially by students, may result in bulbs fusing and give rise to other maintenance problems. And since he was in-charge, only he would have to do the running around to make it functional every time. The chairman not only assured him of the sincerity of students in the department but also promised to provide him a dozen bulbs and the necessary maintenance help when required. The professor explained that such values of co-operation are inculcated from the beginning, and it helps in enhancing the process of group building. Though individuals later drift on the basis of differences of opinion on different issues, research work never suffers. This to some extent illustrates how values in accordance with the definition of goals, accounts for the success of Bangalore and the relatively low-profile of other departments. Of course, a lot also depends on conflict handling styles in the various departments.

To summarise, we can say that some explanations for the low level of internal collaboration, as evident from authorship patterns of published papers has been found. The main barriers seem to be vast differences in age, diffused interests, high competition if they have similar interests and personal problems. All these factors reflect highly on the research goals (and lack of them) and policy of expansion. Besides, problems do arise

even when growth is directed (as shown in the case of Bangalore) and success is ensured by tactful handling of their problems.

6.4 EXTERNAL INTERACTION

The main concern of this section is an analysis of the dynamics of external interaction pattern of our scientists, both within the country and outside. Taking collaboration of research papers with outsiders as indicators, detailed analysis on the informal interaction patterns of the scientists is undertaken. The discussion is supplemented with the conference participation, and association membership of the respondents and their interaction with the larger society.

6.4.1 Collaboration with Outsiders:

As data analysis in Table 6.2 shows, collaboration with outsiders is significant in three departments. Baroda Y, Madras A and Madras C. In our earlier discussion on internal interaction, we found that in two of the above mentioned three departments, collaboration with colleagues within the department was very low. Vast age differnces and lack of active researchers inhibited internal interaction in Baroda Y. Diffused expansion and severe competition among those of similar interest were cited as reasons for low internal collaboration in Madras A. Greater external interaction in these two departments is, to some extent then, understandable. On the other hand, we find respondents of Madras C do have strong internal interaction and also significant

external collaboration. Data analysis in the earlier chapter showed that members of this department - both theoretical and experimental Nuclear physicists - worked together from time to time depending on the problem chosen. What then makes them seek the help of scientists in other institutions? A detailed breakup of this external collaboration patterns will enable us to have a better understanding of the functioning of scientists from Madras C and also highlight the differences across departments in this respect. Table 6.5 provides the details.

Some striking featurees of the table are: (i) a very high rate of collaboration with scientists in foreign countries, and (ii) very low collaboration with scientists in other Indian universities. Only two departments, Madras A and B, show any trace of collaboration of the later kind. The universities referred to by Madras A scientists are Annamalai, Madurai Kamaraj and the Trichy Centre of the same university. Their domains of collaboration therefore are limited to the universities within the same state. It is quite probable that physicists who engage in such collaboration are former students of these departments, and hence engage in some joint work with their former teachers. For the scientists of Madras B it is Bangalore and Hyderabad, which are located in the two neighbouring states of Tamil Nadu.

In contrast, a majority of external collaboration nationally, for all departments are with scientists from advanced research institutes. It is largely with PRL in Ahmedabad and

TABLE 6.5

CO-AUTHORSHIP PATTERNS WITH OUTSIDERS

UNIVERSITIES	TOTAL NO. OF PAPERS CO-AUTHORED	INDIA			FOREIGN	
		UNIV.	RES. INSTIT-UTE	INDUS-TRIES	UNIV.	RES. INSTI-TUTE.
BARODA (X)	1	1	0	0	0	0
(Y)	33	0	33	0	0	0
MADRAS (A)	114	7	8	0	82	17
(B)	23	6	2	0	13	2
(C)	61	0	30	0	19	12
BANGALORE	75	0	7	0	66	2
DELHI	23	0	4	0	19	0
TOTAL	330	14	84	0	199	33

BARC in Bombay for the Baroda scientists. The number of such papers are comparatively low for Madras A and B physicists. The institutions are NCL-Pune (National Chemical Laboratory) and CCMB-Hyderabad (Centre for Cellular and Molecular Biology) for Madras A physicists and CTS-Bhuvaneshwar (Centre for Theoretical Studies) for Madras B physicists.

The Nuclear physicists of Madras C on the other hand have a large number of papers with scientists in research institutes. Institutions mentioned are TIFR - Bombay, SINP (Saha Institute of Nuclear Physics) in Calcutta, IIT-Madras, and the Atomic Energy Centre at Kalpakkam which is close to Madras. While the external collaboration within India in departments other than Madras C seems to be based on individual contacts, it seems to be directed and department-oriented in case of Madras C scientists.

The research institutes mentioned by the Bangalore scientists are TIFR and BARC Bombay. The Delhi scientists mentioned the name of IIT, Kanpur, besides those of the above-mentioned institutes.

What is of interest to us is the large number of co-authored papers with scientists in foreign universities. We find that such collaboration is totally absent for the Baroda scientists. For the Madras A physicists we find that it ranges from Cavendish in U.K. to British Columbia in Canada. However, a majority of the papers are with faculty of American universities, such as Cal Tech, Princeton, Texas, Wisconsin, Utah and Pittsburgh. This

largely diffused nature of external collaboration only points to the fact that they are all independent efforts and are based on individual contacts. Most of the faculty members had been abroad for their higher education or for post-doctoral work. They maintain contacts with scientists abroad and are found to be visiting these universities regularly even after return to India. The research institutes abroad mentioned by the respondents include the National Institute of Health (NIH) - U.S.A. and National Research Council (NRC) - Canada.

The situation seems similar for the Madras B respondents, i.e. collaboration with universities, where they had studied. They include Brandeis and M.I.T. in U.S.A., Alberta in Canada and Oxford in England. On the contrary, for the physicists of Madras C collaboration has been largely with scientists working in the Swedish Atomic Energy Agency at Uppsala, Sweden and with scientists in the Argonne National Laboratory, U.S.A.. However, some universities like Washington, Catholic University in U.S. and Virginia and McGill in Canada are also mentioned where they have collaboration but not regularly.

The nature of this directedness of collaboration is even more significant with respect to the Bangalore scientists. Purdue in the U.S. and British Columbia in Canada seem to be the constant collaborators. A few other universities like Princeton, Columbia and Wayne State University also figure, but very occasionally.

For respondents of Delhi, collaboration again is diffuse and based on individual efforts. Universities referred to are largely in the U.S., like Chicago, Syracuse, Illinois, Colorado, Texas and the University of California at Los Angeles.

In sum, we can say that joint research work with foreign scientists has been significantly high in all departments, but seems directed only in two - Madras C and Bangalore. Collaboration here has been department-oriented and seems to be related to research goals of the department as a whole. In the remaining departments, they are highly individual oriented and hence very much diffuse. However, this nature of external collaboration would be better understood with an analysis of the informal external communication patterns of our scientists. Reasons for the greater preference for foreign scientists over scientists in India may also emerge.

A detailed discussion of the informal communication patterns among our respondents would in some sense help us understand better the reasons for what is often referred to 'as a fragile scientific community' in India or the absence of a scientific community, or the notion of 'communities of scientists'.

7.4.2 The Span of External Contacts

Two main aspects of the nature of external contacts of the respondents will be discussed here. These relate to (a) the kinds of target institutions involved along with types of

interaction and (b) the differences between departments with regard to the directedness or diffusedness of contacts.

Turning to the first, the target institutions (of contact) have been classified as 'National' and 'International' and the types of interaction as follows: (i) Informal discussions, (ii) Regular correspondence, (iii) Research collaborations, and (iv) Visits to institutions. These, like different points on a sociometry scale, indicate the preferences of respondents with respect to whether their contacts are directed towards one or a few institutions, or are diffused, in the sense that various faculty members establish varied contacts independently with a variety of institutions.

Details in Tables 6.6, 6.7 and 6.8 show that the target institutions are largely the research institutes rather than universities of the country, be it for purposes of informal discussions, visits or collaborations. Only occasionally they are with neighbouring universities. Besides, the departments that conduct predominantly experimental research have greater external contacts, probably for gaining access to experimental facilities. However, two factors seem to be of significance for research collaboration (a) nearness to their institution or (b) directed towards such institutions where scientists work in areas of similar interest. Madras A and B are examples for the former and Madras C for the latter.

TABLE 6.6

NATURE OF EXTERNAL INTERACTION - NATIONAL
INFORMAL DISCUSSIONS

UNIVERSITIES	TARGET INSTITUTIONS
BARODA (X)	National Physical Laboratory - Delhi Sardar Patel University - Gujarat.
(Y)	Physical Research Laboratory Ahmedabad Pune University and Regional Engineering College - Surat (Gujarat).
MADRAS (A)	Indian Institute of Science - Bangalore Tata Institute of Fundamental Research - Bombay and Indian Institute of Technology - Madras.
(B)	Institute of Mathematical Sciences - Madras, Indian Institute of Science - Bangalore, Indian Institute of Technology - Kanpur Indian Statistical Institute - Delhi and Trichy Centre of Madras University.
(C)	Indian Institute of Science - Bangalore and Bhabha Atomic Research Centre - Bombay.
BANGALORE	Bhabha Atomic Research Centre & Tata Institute of Fundamental Sciences - Bombay; All India Institute of Medical Sciences and Indian Agricultural Research Institute - Delhi; National Drug Research Institute - Lucknow; Centre for Cellular and Molecular Biology - Hyderabad; Association for Cultivation of Sciences and Institute of Chemical Biology - Calcutta, Madras and Delhi Universities.
DELHI	National Physical Laboratory, Indian Institute of Technology & Jawahar Lal Nehru University - Delhi; Indian Institute of Science - Bangalore; Tata Institute of Fundamental Research - Bombay; Physical Research Laboratory - Ahmedabad; Uttar Pradesh State Observatory - Nainital; Raman Research Institute - Bangalore; Banaras Hindu University and University of Hyderabad.

TABLE 6.7

NATURE OF EXTERNAL INTERACTION - NATIONAL RESEARCH COLLABORATION

UNIVERSITIES		TARGET INSTITUTIONS
BARODA	(X)	-
	(Y)	Drug Control Laboratory - Baroda; Physical Research Laboratory - Ahmedabad and Bhabha Atomic Research Centre - Bombay.
MADRAS	(A)	Indian Institute of Technology, Institute of Ayurvedic Medicine, Madras Medical College - Madras; Indian Institute of Science - Bangalore; Bhabha Atomic Research Centre, Bombay University - Bombay and Madurai University.
	(B)	Indian Institute of Technology, Institute of Mathematical Sciences - Madras; Trichy Centre of Madras University and University of Hyderabad.
	(C)	Indian Institute of Technology, Institute of Mathematical Sciences - Madras; Bhabha Atomic Research Centre and Tata Institute of Fundamental Sciences - Bombay; Regional Research Laboratory - Kalpakkam and Defence Research and Development Organization - Bangalore and Hyderabad.
BANGALORE		Indian Institute of Technology - Bombay; National Chemical Laboratory - Pune and Delhi University.
DELHI		College Teachers of Delhi University, National Physical laboratory - Delhi; Indian Institute of Technology - Bombay, Kharagpur and Kanpur; Indian Institute of Science - Bangalore; Saha Institute of Nuclear Physics -Calcutta; Indian Space Research Organisation - Thumba (Kerala) and Punjab University.

TABLE 6.8

NATURE OF EXTERNAL INTERACTION - NATIONAL
VISITS TO INSTITUTIONS

UNIVERSITIES	TARGET INSTITUTIONS
BARODA (X)	Physical Research Laboratory - Ahmedabad; National Physical Laboratory - Delhi; Indian Institute of Science - Bangalore; Institute of Science - Bombay; Delhi and Madras University.
(Y)	Physical Research Laboratory - Ahmedabad; Bhabha Atomic Research Centre - Bombay; Indian Institute of Science - Bangalore and Andhra University.
MADRAS (A)	Indian Institute of Technology - Madras; Indian Institute of Science - Bangalore; Bhabha Atomic Research Centre - Bombay.
(B)	Indian Institute of Science - Bangalore; Tata Institute of Fundamental Research and Indian Institute of Technology - Bombay; Indian Statistical Institute - Calcutta; Venkateswara, Andhra and Mysore Universities.
(C)	Physical Research Laboratory - Ahmedabad.
BANGALORE	Indian Institute of Technology - Madras; Centre for Cellular and Molecular Biology - Hyderabad; Association for the Cultivation of Sciences - Calcutta and Delhi University.
DELHI	National Physical Laboratory and Indian Institute of Technology - Delhi; Indian Institute of Technology - Kanpur; Physical Research Laboratory - Ahmedabad; Tata Institute of Fundamental Research - Bombay; Institute of Theoretical Physics - Bhuvaneswar; Vikram, Jaipur, Jammu, Mysore and Kurukshetra Universities.

The only significance of the immediate environment is viewed in case of Baroda Y where our respondents are engaged in consultancy work for the local chemical industries (not given in the Table as contacts with industry are absent for the remaining six departments). At the same time, they also have contacts for research collaboration with scientists from PRL and BARC, apart from their collaboration with the Drug Control laboratory at Baroda. This applied research tendency therefore seems to be a spontaneous disposition as some of our respondents from this department had expressed priority to application value as a key reason for shift in their research interests.

If one looks at the target institutions for the Bangalore scientists, we find that they do have informal discussions with scientists in institutions such as BARC, TIFR, CCMB and Institute of Chemical Biology, Calcutta. One sees that they are in touch with fellow active scientists in the country, but rarely collaborate with them. They also have contacts with scientists in ICRISAT (Hyderabad), NDRI (Lucknow) and IARI which are applied research institutes. These contacts probably help them to pick up interesting problems or are avenues to extend their expertise.

Tables 6.9, 6.10 and 6.11 show the nature of international contacts. For the Baroda respondents, international contacts are largely confined to correspondence, albeit regular. With a little probing we found that this simply referred to correspondence with some former students who had gone abroad for

TABLE 6.9

NATURE OF EXTERNAL INTERACTION - INTERNATIONAL REGULAR CORRESPONDENCE

UNIVERSITIES		TARGET INSTITUTIONS
BARODA	(X)	University of Uppsala - Sweden; Ohio, Connecticut, Washington, California and R.P.I. - U.S.; Institute of Science-Germany.
	(Y)	University of Paris - France; Madrid - Spain; Masachussetts, Wisconsin, Texas and Naval Research Laboratory - U.S.; Glasgow and Strathclyde - U.K.
MADRAS	(A)	University of Uppsala - Sweden; York, Glasgow and Oxford - U.K.; University of New York, Cal Tech., NASA, National Institute of Health and Tenesse - U.S.; Ottawa, British Columbia - Canada; Victoria - Australia.
	(B)	Edmonton - Canada; Texas, UCLA, Boston - U.S.
	(C)	University of Uppsala - Sweden; Budapest; Ghent; Michigan, Los Alamos Laboratory - U.S.; Israel University.
BANGALORE		Carnegie Melon, University of New York - U.S.
DELHI		Boulder, Syracuse, Milwaukee, Iowa, Penn. State - U.S.; Bristol, Manchester - U.K.; British Columbia - Canada; Astrophysics Laboratory - Belfast.

TABLE 6.10

NATURE OF EXTERNAL INTERACTION - INTERNATIONAL RESEARCH COLLABORATION

UNIVERSITIES	TARGET INSTITUTIONS
BARODA (X)	-
(Y)	-
MADRAS (A)	National Research Council, British Columbia - Canada; Cavendish - U.K., Cal. Tech., Princeton, Texas, Wisconsin, Utah and Pittsburgh - U.S.
(B)	Brandeis, M.I.T., State University of New York - U.S.; Alberta, Edmonton - Canada.
(C)	University of Uppsala - Sweden, Catholic University, Argonne National Laboratory - U.S.; Mc Gill - Canada; Frankfurt; Belgium.
BANGALORE	Ann Arbor - Michigan, Connecticut, Illinois, Columbia, Washington and Purdue - U.S.; British Columbia - Canada; Italy; Germany; Israel.
DELHI	Penn. State, Fermi Laboratory, Rochester, Pittsburgh and Chicago - U.S.; National Research Council - Canada; Vanderbuilt Meteorological Institute - Denmark.

TABLE 6.11

NATURE OF EXTERNAL INTERACTION - INTERNATIONAL VISITS TO INSTITUTIONS

UNIVERSITIES	TARGET INSTITUTIONS
BARODA (X)	University of Uppsala - Sweden.
(Y)	-
MADRAS (A)	State University of New York - Buffalo, Silicon Valley - San Francisco and Wisconsin - U.S.; International Centre of Theoretical Physics - Trieste - Italy; German Exchange Fellowships.
(B)	-
(C)	University of Uppsala - Sweden; U.K. Atomic Energy Agency; Science Centre - Frankfurt.
BANGALORE	Purdue, Chicago and other universities in U.S.; Universities in U.K.; British Columbia - Canada.
DELHI	Boulder, Fermi Laboratory, Clarkson and other universities in U.S.; Observatories in Paris and Belfast; Moscow; W. Germany.

their higher education. Otherwise, it referred to the exchange of letters, while making requests for reprints of research articles published in international journals.

There are however, some similarities in the nature of contacts for the respondents of Madras A and Delhi. It may be recalled that several of the faculty of these two departments have had some training abroad at the doctoral or post-doctoral level. Their contacts are with scientists and institutions they are familiar with. They make efforts to retain them which enables them to make short trips abroad from time to time. The academic contacts are, therefore, 'individualistic', diffused and sporadic.

Conversely, the external contacts of Madras C and Bangalore show regularities. The same institutions are the targets of correspondence, collaboration and visits. This reflects the organised functioning of these two departments with clear overall research perspectives and goals. The academic-contacts - international for these two departments therefore are directed, institutional, regular and systematic.

To sum up the discussion on the nature of external contacts, there are only two significant features. As far as external contacts within the country are concerned, we find that our respondents from universities have a tendency to build contacts with scientists in other advanced research institutes rather than universities and try to sustain the contacts by visits to such

places and by regular correspondence. When it comes to international contacts, two patterns emerge. If the department as a whole has specific goals and perspectives with reference to research, then the external contacts are directed, in which case the individual members have little role to play in building those contacts, as seen in the case of Madras C and Bangalore. But in the absence of such clear perspectives, the individuals have to make conscious efforts either to build or to retain their contacts as seen in the case of respondents from Madras A and Delhi.

As for the need for such external contacts, several reasons have been cited by the respondents. For the Baroda Y respondents, it is the lack of active researchers within the department that leads to low internal interaction and high external contacts. On the other hand, though there exists strong internal co-operation in Madras C, the nature of the research area -- Nuclear physics and the lack of sufficient infrastructural facilities necessitates their external contacts, which has been shown to be well directed.

For the relatively well integrated group of scientists from Bangalore who are also sufficiently provided with sophisticated instruments, well directed external interaction is for different reasons. Their purpose is to be in touch with the latest problems in their research area i.e. Molecular Biophysics and therefore the need for regular visits abroad. Within the

country, keeping in touch with institutions where scientists work in the same area or similar areas of research is (i) to get acquainted with scientists in the country (though they hardly collaborate with them) and (ii) to be on the look out for young promising research scholars who may be absorbed in their group later.

For the respondents of Madras A and Delhi, reasons are mixed. It could be due to high internal competition as several of them work in the same area but do not function as a group. It could also be due to the fact that they have friends in other institutions. Visits abroad and to advanced research institutes within their country as opined by a Delhi respondent also add to their prestige, both amongst their colleagues and in the larger society.

6.5 CONFERENCE PARTICIPATION OF RESPONDENTS

Conferences serve as an avenue, not only for scholars to present their ideas or research results, in order to get quick feedback from the scientific community, but also serve as platforms to acquaint themselves with scientists working in similar areas or on similar problems. Conferences, seminars, symposia and schools are therefore important for the creation and dissemination of knowledge. The underlying objective of such meetings is primarily academic. The following analysis discusses the participation of our respondents in such academic forums.

From the details in Table 6.12, it is clear that respondents across all the seven departments have higher attendence in national level conferences than international ones. This, the respondents opined, is largely due to the following reasons:

(1) To scientists in universities, travel grant is almost rarely available from the universities. So when papers are accepted in international conferences they have to try for funds from outside funding agencies like the UGC, DST etc., which is not easy. Then there is the routine bureaucratic procedure to be gone through which very often becomes a strong disincentive for the scholars to go abroad.

(2) There are very few international conferences held in India, and hence participation in the same is limited.

The above observations can be illustrated by the following experience narrated by a scientist. A very senior professor from Delhi had applied for travel support to some agencies fairly well in advance and had even booked his ticket to attend a conference abroad. As there were only two weeks left and no response from the agencies was forthcoming he made some attempts to find out the status of his papers. To his shock he realised that they had not moved at all. He then tried to put pressure on the bureaucrats so that the process could be expedited. But the matter could not be finalised by the time he was due to leave. The net result was that he had to cancel his trip due to want of funds. Such pressure and running around was possible only

TABLE 6.12

CONFERENCE PARTICIPATION OF RESPONDENTS -
AVERAGE NUMBER PER RESPONDENT

(76-85)

UNIVERSITIES	STATE/ GENERAL	NATIONAL CONFE-RENCE	REFR-ESHER SCHOOLS IN INDIA	INTERNATIONAL		SAMPLE SIZE OF DEPART-MENTS
				IN INDIA	IN ABROAD	
BARODA (X)	1.3	3.1	0.5	0.2	0	14
(Y)	0	1.5	0.8	5.0	0.1	12
MADRAS (A)	0	6.2	0.6	2.9	2.5	13
(B)	0	4.4	0	0.7	1.7	9
(C)	0	18.5	0	2.5	3.6	6
BANGALORE	0	6.8	0	1.4	2.8	9
DELHI	0	8.8	1.3	1.5	3.5	24

because he was located in Delhi. If such is the experience of an established academician, it is only natural that the youngsters feel totally discouraged to make any effort in this direction.

Nevertheless, we find that our respondents have attended international conferences both within and outside country. It should be noted here that respondents of departments like Madras A & B, Bangalore and Delhi had been abroad for doctoral or postdoctoral work. Hence many of the conferences they had attended were when they were already outside the country.

However, what is of greater interest to us is the nature of conference participation of the respondents from the different departments. Based on the information provided we have the following types of participation.

(a) Conference Goers : Mainly Listeners

To this category belong our Baroda respondents. The average number of conferences per respondent (Table 6.12) from Baroda X, though not high represents their enthusiasm to participate in all types, wherever they could manage to attend except the international ones held abroad. However, they do not present papers always. Refresher Courses are the ones which they enjoy and enthusiastically participate in, for their knowledge gets updated through them. The significant participation in international conferences (held in India) for the respondents of Baroda Y largely refers to the few active young professors of the department.

(b) **Conference Listeners and Speakers**

Respondents of Madras C who belong to this category have highest averages. They consider conferences as integral to academics. This department is comparatively small with only 6 scientists. Though we find all of them enthusiastic to attend conferences, yet only the two senior professors are highly mobile. However, they are of the opinion that very little academic exchange takes place in such gatherings, for a participant hardly gets ten minutes to present his paper. This indeed is too short a time to even grasp the problem properly.

(c) **Conference Speakers Only**

Respondents from Bangalore and Madras B feel that conferences are of marginal value and avoidable if possible. The highly research oriented Bangalore scientists feel that conferences are merely an excuse to get friends over and hence standard of papers suffers. Their attendance therefore is only as invited speakers who are paid travel grants by the organizers. They generally encourage their students to attend for they feel that casual participation cuts into their research time. However, there is no data that confirmed that low conference attendance is inversely proportional to research publications. The theoretical physicists of Madras B are of the opinion that such gatherings are mainly for the purpose of building contacts, friendship etc., which may be useful in the academic endeavours of junior scientists. When project proposals

are submitted to funding agencies, they are generally approved only on favourable referee reports and hence prior familiarity with scientists working in similar areas may be helpful. They feel that little academic exchange takes place in such forums and senior professors use such gatherings to make informal arrangements about membership in selection committees, placement of students, project funds and other academic and quasi-academic activities.

(d) **Conference Speakers and Organisers**

The last category constitutes an interesting group, for this represents scientists who are more interested in getting people together and making others speak than doing it themselves. Respondents of Madras A and Delhi have many scientists of this kind in their departments. They are enthusiastic in arranging get-togethers -- from refresher schools to international conferences. However, respondents of Madras A feel that larger conferences become monotonous and favour smaller and specialised groups. They take pride in having organised international seminars where national and international celebrities have attended, given lectures and presented papers.

The Delhi scientists are a step ahead of the Madras A physicists. As their department is located in the capital, eminent national and international scientists do visit them. Besides, with greater proximity to all the ministries and funding

agencies they easily organise conferences, workshops and schools not only regularly in their department, but also in other cities within the country. Some of them were only too casual about conferences organised by others for they said that their students generally attend such conferences.

The above classification, it should be noted presents a general pattern observed among scientists from the seven departments. Some individual differences do exist. For example, all Delhi scientists interviewed were not organisers, nor all Baroda respondents only listeners in conferences.

6.6 SCIENTIFIC SOCIETIES, ACADEMIC ASSOCIATIONS AND UNIVERSITY PHYSICISTS

Our discussion of the association membership of respondents is classified in the following way. We first discuss the nature of membership of respondents in the seven departments in foreign associations. The remaining three sub-sections mainly deal with their membership and participation in Indian bodies. These have been classified as specialised research bodies, general physics associations and popular science and activist movements. The relevant data will be discussed under the different headings.

6.6.1 Membership of International Associations

Before going on to study our respondents' affiliation with foreign associations, it is perhaps relevant to mention at this point about conditions under which they become members of foreign

associations. While discussing the educational background of our respondents, it was found that more than 50% of the faculty members of all departments, except Baroda, had been abroad, either for their doctorate or for their post-doctoral work. Besides, they also visit universities abroad fairly regularly on various academic assignments.

All those who went abroad, be it to U.S., U.K. or Canada, had become members either of specialised or general bodies of those countries and tried to continue their membership on return too. Another condition under which some respondents have become members of international bodies largely relates to the senior professors of the seven departments. Due to their academic visibility or status, they are members or elected fellows of international bodies. However, this kind of membership was found more amongst the professors of Madras A and C, Bangalore and Delhi. This type of membership is independent of one having been abroad for higher studies or short visits.

As for membership of foreign associations, Delhi comes first and Madras A next, though between them there is a wide gap. At the other end are Madras B and Bangalore with membership in very few bodies. The explanation for the situation of Delhi and Madras A is rather straightforward. Membership is due to the conscious efforts of the individual respondents.

The members of Madras B weigh their membership of foreign bodies in terms of the benefits that may be derived. They are

satisfied with good exchange of pre-print system and therefore, do not find the necesity of any external affiliation to initiate or enhance interaction. A remark of a respondent of this department about the American Physical Society deserves mention. He said, 'It was a very serious association once, but topics covered these days are not of much interest to us. The only advantage is that one gets journals at a discount, which is anyway available in the library'.

The reason for the general apathy or indifference of the Bangalore respondents towards foreign associations is different. The department is highly research-oriented, with specific goals and clear perspectives. As for their contacts with foreign institutions, the earlier sections on research collaboration has shown that these are specific and directed. Such contacts are with a small number of research laboratories where research in the frontiers of Molecular Bio-physics is being conducted. This being the case, our Bangalore respondents do not find it necessary to get to know people by becoming members of foreign associations.

There are two more factors that have to be highlighted in this section on membership of international bodies (i) the difference in the kind of membership between Madras A and Delhi and (ii) the status of the remaining three departments - Baroda X and Y and Madras C.

To begin with, we find that the membership of the faculty of Madras A is direcrted towards specialised bodies of crystallography. Therefore, the associations include:

i) the International Union of Crystallography

ii) the American Crystallography Association

iii) the American Association for the Advancement of Science

iv) the British Association for Crystal Growth.

The respondents seem to be generally satisfied with their membership, since these associations act as strong lobby groups for research areas in the relevant specialisations, as a respondent put it. Further, they are of the opinion that these associations bring out quality publications. Another respondent made observations as : 'direct benefits are few, but one feels good to be a member'.

In contrast, the respondents of Delhi have memberships both in general bodies and in specialised ones. The key associations of which physicists of this department are members include :

i) The Institute of Physics, London

ii) The New York Academy of Sciences

iii) The Japanese Physical Society

iv) The International Astronomical Union

v) The Royal Astronomical Society, and

vi) The International Leprosy Association.

vii) The American Physical Society

As for general bodies such as the American Physical Society, they

became members while in the U.S., but have found it difficult to continue, their membership after return. The main benefit is that the journals can be procured at a discount. However, they feel that subscription rates in recent times, have become too expensive for them inspite of the discount. Unlike many other associations, the Institute of Physics, London is one, of which some respondents are elected members. Membership is thus like an award, and members get a bulletin which carries news about frontier areas and other relevant academic information. Though they feel unhappy that they are unable to make proper use of such information in India, yet they feel good that they are made aware about recent advances in the field.

As for their membership in specialised bodies, some continue membership passively just for the sake of journals, bulletins or newsletters. These may not be directly useful but again keep them abreast with the latest in their field. Some respondents discontinued membership purely due to financial constraints.

Turning then to the three departments, namely Baroda X and Y and Madras C, we find a very small number of respondents had membership in general associations where membership is through subscription. Such associations are:

i) The American Physical Society

ii) The European Physical Society

iii) The Canadian Physical Society

iv) The Japanese Physical Society

v) The Institute of Physics, London.

Some of the respondents however, have discontinued their membership due to financial constraints and also due to the fact that they are not actively engaged in research. This is true mainly for Baroda respondents. However, the respondents of these departments have not expressed any discontent over this situation for different reasons. While in the case of Baroda it is due to the lack of ambition, in case of Madras C regular contacts with the Swedish laboratory at Uppsala, keep them updated of the latest in their field. Therefore membership of associations for the sake of information is not essential for them.

6.6.2 Membership of Specialised Indian Associations

Respondents from only three of the seven departments Madras A, Bangalore and Delhi are members of such associations. However, the associations vary with departments. The respondents of Madras A are members of specialised bodies like

(1) The Biophysics Society of India

(2) The National Committee on Crystallography

Oriented towards research in Crystallography and Biophysics they show enthusiasm in gaining membership of such bodies. However, the members are not very satisfied, especially with the Biophysics Society as in their view a lot of in-fighting for

positions and power results in un-organised and an ineffective way of functioning. Yet they continue membership because they feel that it is the only academic body that relates to their specialisation within the country.

Turning to Bangalore, as evident from Table 6.13 membership of respondents is only in specialised associations within the country. Most important of these are :

(1) Society of Biological Chemists

(2) Guha Research Conference

(3) Indian Biophysical Society

(4) Indo-Phytopathological Society

However, as preferences go, it is the Guha Research Conference that the respondents value most. Some respondents refer to this association as a 'learned body'. One hears remarks like 'deals with intensive thinking of science', 'the annual conference gives scope for a good exchange of information and involved discussion' etc. Memberships in other bodies is primarily to retain the links with the rest of the community working on similar areas of research. They attend annual conventions of these associations occasionally and keep track of bright youngsters whom they feel it may be worthwhile to train.

For the Delhi respondents, membership of specialised associations include the following :

(1) Plasma Science Society of India

(2) Indian Space Research Association

(3) Indian Astronomical Society

These respondents are generally active members of these bodies. They have initiated the publication of newsletters and bulletins, organised lectures, conventions etc., and have accepted positions of responsibility in these associations. Many respondents took pride in making observations such as 'I was a Founder Secretary/Executive Member'. There were also others who felt that membership in such associations had no meaning, as the journals brought out by them were in any case available in their university library.

Apart from the above, we find that some Baroda respondents are members of some specialised bodies like Laser and Spectroscopy Society of India, The Amateur Astronomical Association and The Acoustical Society of India. These, it may be noted, represent membership mainly of some very few senior professors, who are actively engaged in research. Unlike other departments, membership of specialised associations is not considered as important by readers and lectures.

6.6.3 Membership of General Physics Associations

The data in Table 6.13 shows that irrespective of the departments and the faculty status, the one association that figured throughout is the Indian Physics Association (IPA). Barring the department of Molecular Bio-physics of Bangalore all other departments have members in this association. However, the

TABLE 6.13

MEMBERSHIP IN SCIENTIFIC SOCIETIES, ACADEMIC ASSOCIATIONS

UNIVERSITIES	PROFESSORS		READERS		LECTURERS	
	INDIAN	FOREIGN	INDIAN	FOREIGN	INDIAN	FOREIGN
BARODA (X)	IPA, Ind. Phys. Society, IAPT & ISTE	Phys. Society Japan, Inst. of Physics, London	IPA, Ind. Phys. Society Laser & Spectroscopy Soc. of India, IAPT Amateur Astronomical Assoc.	-	Ind. Phys. Soc. Ind. Academy of Sciences, Marathi Vigyan Parishad, IPA and IAPT	-
(Y)	IPA, Ind.Phys. Society Ind. Assoc. for Radiation Phys. (IARP), ISTE, IAPT, Marathi Vigyan Parishad	-	Acoustical Soc. of India, IPA, IAPT, ISTE, Marathi Vigyan Parishad	-	IPA	International Solar Energy Agency
MADRAS (A)	IPA, T.N. Acad. of Sciences, Indian Bio-Phys. Society, Space Science Programme, Nat. Information Centre for Crystallo-graphy, Nat. Committee for International Union of Crystallography	International Union of Cry-stallography, American Crystallo-graphy Assoc., American Association for Advance-ment of Science & SIGMAXI	IPA, T.N. Academy of Sciences, National Crystal Data Centre	British Association of Crystal growth	IPA, T.N. Academy of Sciences, Science Circle of Bangalore	American Crystallo-graphy Assoc. Interna-tional Union of Crystallo-graphy.
(B)	INSA, Ind. Acad. of Sciences, T.N. Academy of Sciences, IPA	-	IPA, PPST, MUTA	-	IPA & PPST	American Physical Society

(C)	IPA, T.N. Acad. of Sciences, MUTA, Southern Regional Council of Cryogenics, Ind. Assoc. of Radiation Physics, CSI, ISTE, Optical Soc. of India	American Physical Soc., Canadian Physical Soc., European Physical Soc..	IPA	-	Indian Bio-physical Society & IPA	-
BANGALORE	INSA, IAS, Soc. of Bio-Chemists, Guha Res. Conf., Nat. Committee for Crystallography	International Union of Crystallography	Bio-Phys. Society, Ind. Phyto-Pathology Soc., KSCTC, Guha Res. Conf.,Soc. of Biolog. Chemists.	-	-	-
DELHI	Ind.Phys.Soc., Inst. of Telecom. Engrs., Planetory & Space Science Assoc., Plasma Science Society of India, Ind. Astronomical Soc. for General Relativity.	American Geophysical Union, Int. Astronomical Union, Royal Astronomical Soc., American Phys. Society, N.Y. Academy of Sciences.	Nat. Academy of Science, IPA, IAPT, Ind. Academy of Medical Physics, IAPT, Plasma Science Society of India, Hoshangabad.	American Physical Soc., GIREP (Hungary) Japan Phys. Soc. Internat. Leprosy Association, American Geo. Phys. Union, Inst. of Physics, London	Would like to become a member of DUTA	IEEE, SCHNE, IMAP.

reasons cited for becoming a member and retaining membership and the remarks made regarding the activities of the association varies from department to department. These remarks can be better appreciated if viewed in the context of the teaching obligations and the research activities of these departments.

This association has its headquarters in Bombay and its impact is relatively great in the western region. It has chapters all over the country; in certain states more than one. Its activities as indicated by the respondents, include holding of annual conventions, refresher schools occasionally and publication of a journal, Physics News. The journal seems to be the real link among its members. Let us now consider the reactions of the respondents to the association and its activities as a whole.

The general feeling of the Baroda respondents is one of satisfaction. They are of the opinion that the objectives of the association are laudable, such as to improve the overall quality of physics teaching in India. It aims to evolve new methods of teaching and also to restructure syllabi of courses. Thus it directly helps the college teachers. Lectures about current research areas from time to time keep them informed about frontier areas in research. The association thus initiates interaction amongst the members of the physics community and also between the physics community and the larger society. While large number of members are active participants, there are

passive members of this association too. The general complaint is that there is no follow-up of any activity. Nevertheless, a few respondents expressed the view that they found the conventions organised by the IPA as platforms for people with low standards to express themselves and that they were just excuses for extra academic purposes such as appointment of examiners, experts for selection committees for the senior physicists and sight-seeing trips, to build contacts with seniors etc. for those at the junior level in the profession.

On the other hand, the respondents of Madras and Delhi who are members of IPA are not too excited about this association. They are generally passive members of their respective chapters and pay subscription only when collected. However, they are aware that they are the ones who should make it a meaningful organisation and they also realise that it is active in some parts of the country. One respondent, quite emphatically pointed out that since it has no say at the national level in terms of science policy, he does not care much even if he is not a member of the IPA.

Besides the IPA, there are three other general physics associations, which have membership in atleast three of the seven departments. They are (i) the Indian Physical Society, (ii) the Indian Association for Physics Teachers (IAPT) and (iii) the Indian Society for Technical Education (ISTE).

The Indian Physical Society has some members in the two departments of Baroda and Delhi. This association has its headquarters in Calcutta and is primarily active in the eastern region of the country. However, quite a few respondents feel that it is almost defunct these days. The activities mainly include holding of annual conventions. Earlier, these conventions were oriented towards research activities but later included pedagogical activities of direct interest to college teachers. But according to the Baroda respondents, the efforts of the members instead of being directed towards the development of science, got diverted to a range of extra academic activities. One respondent even found some justification for the latter, by saying that the ambition of the Indian scientists is to remain in the spotlight, somehow. He conceded that there may be a few serious minded scientists, but they are surrounded by non-serious people which adversely affects any association. The membership and participation of the Delhi respondents is minimal and in any case passive.

The association purely devoted to the teaching of physics in India is the Indian Association of Physics Teachers. Membership of this association is again from the two departments of Baroda and Delhi. However, the impressions they carry about the association are quite dissimilar. Since the two departments of Baroda are primarily teaching-oriented, this association is of great relevance to the respondents there. They support its

activities which include holding of annual conventions and refresher schools and most importantly, publication of their bulletin which caters totally to the teaching of physics in India. The papers are concerned with innovations in teaching methods, modification of syllabi etc., One respondent went to the extent of saying that he might not be an active member, but certainly felt good to be associated with it. In contrast, the members of this association from Delhi expressed their indifference, because it is basically pedagogically oriented and not research oriented.

Another academic association that has members in three departments of our sample, Baroda X and Y and Madras C, is the Indian Society for Technical Education. Of the three departments, the largest membership is from Baroda Y. It is possible that, the department being located in the Faculty of Technology of M.S.U., exposure to this association is greater for the respondents from this department. They have a favourable opinion about its activities which include organising summer and winter schools sponsored by the UGC. Participation in these has helped them to even introduce new courses and modify the existing ones. Though at times they feel many of the lectures are predominantly theoretical, they are hopeful that these will be of use to them some day. In contrast, the respondents from Baroda X and Madras C were rather passive in their attitude towards this

association and did not have anything substantial to say about them.

One other association very specific to the university is the Tamil Nadu Academy of Sciences. Respondents from all three departments of Madras are members of this association. This organisation was founded by Dr. Malcolm Adiseshiah, a former Vice Chancellor of the same university. It is located in the university campus. The main concern of the body has been to educate people regarding the relevance of science to society and as such membership is open to specialists and non-specialists alike, including local bureaucrats, educationists, ministers etc.. Our respondents generally have strong reservations against such associations where scientists and social scientists are treated alike and as a consequence, are mainly passive members of this association. Some even go to the extent of expressing resentment against forming such organisations.

6.6.4 People Science and Activist Movements

The respondents from Baroda are keenly interested in associations like the Marathi Vigyan Parishad, the major goal of which is to take science to the masses. Some of our respondents remarked that they have an urge to tell others about science, and that the students are not always the best audience. Students, they say, first of all, do not attend even their classes regularly and even if they do, are not really motivated to learn

anything that does not directly relate to their subject. So they have found membership of Marathi Vigyan Parishad or the Gujarati Vigyan Mandali quite satisfying.

Similarly, a few members of Madras B, i.e., the Theoretical physics department, are quite involved in popular science movements like the Patriotic and People Oriented Science and Technology (PPST). They do not feel the need to become members of academic associations to keep in touch with the latest in their research area due to an effective pre-print exchange system. In their opinion, they do have time, therefore, which they devote to the popularisation of that science which is relevant to the people.

One other department that has membership in such movements is Delhi. The growing social consciousness about the evils of modern science on the environment, especially after the Bhopal gas tragedy has motivated some members to join activist movements functioning in and around Delhi. Their interests also extend towards membership in much more established movements like the Eklavya and Hoshangabad science movements, where priority is given education through literacy.

6.7 NON RESEARCH PUBLICATIONS

Just as some respondents are members of the associations which are relevant to the society at large, so do the publication lists of a few scientists include non research work. These

include items such as text-books, lecture notes, guides, edited books of proceedings of a conference, refresher courses etc. Table 6.14 gives some idea about such publications across the seven departments, which cannot be included as journal publications.

Details in Table 6.14 prove interesting when the nature of these publications and the opinion of the respondents towards them are compared across departments. Looking at the data for Baroda X, we find that the respondents have been interested in writing only text-books. It is to be clarified further that these books were written in the regional language, Gujarati. Those who had written such books feel honoured as they had been approached by the state government to do so. Books were basically on science for different audience --school students, college students, science teachers etc. One respondent was of the opinion that these writings are more relevant than research publications as they cater to a larger audience. Besides, such publications have greater monetary return too, he added. There was, however, one respondent who had co-authored a book on statistical mechanics with his colleague. This was in English and in the respondent view a concise text-book. As he found it increasingly difficult to REFER many books in the field for teaching purposes he decided to write one in accordance with the prescribed course syllabus.

TABLE 6.14

NON-RESEARCH PUBLICATIONS

UNIVERSITIES	BOOKS	TEXT BOOKS	OTHERS	TOTAL
BARODA (X)	0	4	0	4
(Y)	0	1	0	1
MADRAS (A)	6	0	0	6
(B)	0	1	0	1
(C)	2	0	0	2
BANGALORE	1	0	0	1
DELHI	4	2	0	6
TOTAL	13	8	0	21

The situation is very different with the Madras A respondents. As evidenced in the table, 6 respondents, 5 professors and 1 reader have written books. They have been published by such publishers like John Wiley and Sons, Pergamon Press and Oxford and IBH. A couple of the books are purely research oriented, for they are a collection of research papers and other research work carried out in the department. The remaining are edited volumes of proceedings of National/International conferences and schools held in the department. Apart from these, a senior professor has been involved in writing a book on musicology for the Sangeet Natak Academy. This he says is very much a scientific production as it is on the mathematical and computer analysis of raga structure.

Only one senior professor from Madras B has written a text-book on Quantum Mechanics (English). Though the general response of the respondents of this department is much against text-book writing, they are nevertheless in praise of the one written by the senior professor from their department. Their opinion is that one should write 'books of some value' and not 'bazaar-text-books', to quote a respondent. However, they are also at the same time concerned about giving the right kind of books to school children. Some have observed serious mistakes in the books produced by NCERT (National Council for Educational Research and Training) which they say badly reflects on the agency for selecting mediocre scientists to write books. One

respondent was involved in editing the proceedings of a conference held elsewhere.

Madras C has some similarities with Madras A. They have held some national & international conferences, proceedings of which have been published as edited volumes. However, a couple of respondents are very enthusiastic about writing text-books for M.Sc. and M.Phil. students as well, as it is basically tough to organise lectures from too many books. One faculty in fact had already applied to UGC for a book grant. A junior faculty of the department made an interesting observation in this regard. He feels that the ideal time to write a book is the post-retirement period, when one has sufficient experience and the time. However, a publication in the form of a book while in service, is a significant addition to one's bio-data and hence at times gives rise to a fall in standards of publication for such books flood the market, but do not contribute to knowledge on the subject concerned.

The sole respondent from Bangalore who has some book-writing experience has edited the Annual Review of a particular research area brought out by a journal. Responses however were mixed. The senior professors who had been approached to write books have not done so for two reasons: (i) their field of research is highly specialised and competitive and hence they feel that any book brought out by them can never be of the same standard as a foreign book (ii) They feel that such endeavour which is

enormously time consuming is not for active researchers -- they would miss out on the latest. A few others feel that though there are large number of books available in the field of Molecular Biophysics, yet there is a need for a simplified elementary version to suit the Indian students. Such opinion was generally expressed by the junior faculty who feel that they are neither qualified nor experienced to write one.

With respect to the Delhi respondents, we find that their contribution is towards all kinds of books. They have been editing volumes of conference proceedings, workshops, refresher schools etc., published by houses such as Macmillan. Those who have written text-books have done so primarily for NCERT for school students from Class 9 to 12. There was however one respondent who had written on general science topics like the SUN for school children as an independent effort. As for their general remarks, some wish to write books for M.Sc. students due to problems of organising lectures, while others feel the need to do so, but do not venture due to the pressure of work or personal limitations. There are yet others who feel that writing such books is a waste of time and not a worthwhile endeavour.

To summarise the main issues and findings of this chapter, we first set out to unravel patterns of collaboration of scientists in various departments, by identifying the co-authors of published papers. Maximum work has always been with research

students. It was also inferred that they had very low collaboration with scientists in other Indian universities and very high priority for scientists abroad. Within India priority is towards scientists in research institutes. This established formal communication was supplemented with a discussion of the informal communication patterns that scientists have with their colleagues, the rest of the scientific community in India and abroad. We found that only two departments - Bangalore and Madras C have very well directed, regular contacts with specific institutions within or outside the country. The remaining departments represent diffused, sporadic and individual forms of external interaction, primarily based on independent efforts. This situation seems to be an outcome of the lack of well defined research and other academic goals for the department and the consequent diffused expansion in terms of recruitment of its faculty members.

In this context, the need for external contacts also varies for the departments. Sufficient infrastructural facilities and an active research group, makes the Bangalore respondents interact with specific laboratories, institutions abroad only to keep in touch with the latest problems and within the country to keep track of young bright talent. For the rest, like the two Baroda departments, Madras A and C to some extent, the very lack of proper infrastructural facilities necessitates external interaction and collaboration.

Interaction with the rest of the scientific community is also reflected in the nature of conference participation. Very much in line with the extent of directedness of department goals, we find that Baroda physicists are mainly conference goers and listeners, Madras C scientists are conference listeners and speakers, but physicists from Bangalore and Madras B are speakers in conferences if at all they attend. The remaining two departments - Madras A and Delhi have several scientists who take active interest in organising conferences and getting scientists to their department.

The nature of membership in academic associations and scientific societies also very clearly tie up with the departmental goals. Respondents of Baroda are largely members of general physics associations and particularly those that pertain to physics teaching in the country, physicists of Madras A take interest in specialised research bodies within the country and abroad and respondents of Bangalore primarily with specialised associations only within the country. The scientists of Delhi show interest in gaining membership in science societies outside the country which gives them a discount on their journals. Similar interests have been found among the scientists of Madras C. Membership in general physics associations in all these departments is generally highly passive.

However, it is interesting to note that Baroda respondents take very keen interest in people science movements that

regularly engage in popularising science. Similarly a few scientists from Madras B and Delhi also take active interest in some regional popular science and activist movements.

The last section of this chapter attempted to see the links our scientists have with the society in some greater detail by analysing their non-research publications. Interestingly, scientists of Baroda who may be considered marginal within the system of stratification in science, were found to be engaged in writing science text books in their regional language very regularly. With increasing regionalism and encouragement to education in the native languages, such endeavours have very serious implications and in the particular context are doing very useful work. The only other department with similar interests is Delhi where the members write science text-books for school children, but generally in English and for NCERT which is a national level organisation.

With this idea of patterns in the external interaction of our scientists, we proceed to discuss in the following chapter the dynamics of visibility and power of the scientists within the scientific community of the country.

CHAPTER VII

FRAGMENTATION AMONG SCIENTISTS: VISIBILITY AND POWER

The main focus of this chapter is the nature of 'visibility' enjoyed by the scientists and its implications for the functioning of of science in the country. 'Visibility' in the traditional framework of stratification in science is confined to the realm of 'Big Science'. It refers to recognition awarded to those scientists who are not only high producers but have also made significant contribution to the growth of 'certified knowledge'. Indicators of 'visibility' are therefore awards, rewards won by scientists and positions of power occupied by them in the bureaucracy of science. We, therefore, propose to discuss the nature of 'visibility' of the scientists in our study in accordance with its major indicators.

7.1 RESPONDENTS AND REWARDS

Rewards and awards, it is understood, are measures of recognition for the contributions of a scientist. There seems to be no definite distinction between rewards and awards according to the respondents. Depending on the priorities of the departments in which they are working and in the context of their immediate scientific community, it varies.

In the case of Baroda respondents, the acquisition of grants from the university or outside agencies is considered as an achievement and a measure of their recognition. As project

proposals are refereed before funds are sanctioned, even a minor research project from the UGC is considered an award. In the words of one of the respondent "it implies recognition for the research work conducted, and long term involvement in research".

For those in Madras A, mainly elected or nominated membership of national, international organisations is an award. This enables them to join the select few scientists in their area get involved in planning or giving direction to the nature of research to be conducted in the country. Continued research and therefore funds from agencies (mostly large funds) are part of their academic activity and are therefore rarely mentioned as awards. They also value conference presentations and some have obtained prizes for the best research paper presented in conferences. For the professors of Madras B any form of national recognition constitutes an award. The respondents of Madras C have not obtained any national level distinction and consider themselves as still trying to get established in the field.

In contrast to the above, we find that five out of the six professors interviewed in Bangalore are Bhatnagar award winners and almost all of them are fellows of the Indian Academy of Sciences and INSA. In addition, as Table 7.1 shows, some have been members of national delegations to attend international conferences. A couple of them also had a number of patents. In sum, one can say that they are well established nationally and

NATURE OF AWARDS

ERSITIES	PROFESSORS	READERS	LECTURERS
DA (X)	Fellow-SIDA, nominated for Univ. research grants, Hari Om Ashram Trust Award for the best res. paper in Physics, Res. funds from UGC, Gujarat State Ind. Council etc.	Research projects from the UGC	Research projects from DST
(Y)	Short and Long term research grants from Univ., UGC, CSIR, etc. Hari Om Ashram Award for best research paper in Physics.	Fellow, Acoustical Society of India, Minor res. grants from UGC, CSIR etc.	-
RAS (A)	Raman Res. Award for the best res. publication, Assoc. member - Inst. of Physics, London, Fellow New York Academy of Sciences, Fellow Nat. Academy of Sciences, Founder Fellow, T.N. Academy of Sciences, Secy. Nat. Committee of Crystallography, Several research grants.	UGC career award for teachers	Best paper award in th Nat. Conference on Crystallography Best thesis of the year year award of IISc Bangalore
(B)	M.N. Saha award, UGC national fellowship, Raman Award for the best research paper.	-	-
(C)	-	-	-
GALORE	Fellow, IAS, Hari Om Trust award for res. in Life Sciences, Fellow INSA, Bhatnagar award, FICCI award in Life sciences, J.C. Bose Medal in Life Sciences ASTRA Chair in Biological Sciences. N.T. Thomal Prize in Advanced Nutrition, Member of delegation INSA to attend international Conference of Biochemistry, C.S. Patel award for best papers published in Biochemistry (MSU), Young Biophysicist award (Int. Congress) Sreenivasaya Memorial award for outstanding research, Vasvik award for Biological Science & Tech., INSA Young Scientist Award.	INSA Young Scientist Medal, Kothari Sciences award for Young Scientist, Kani Medal from Nat. Cancer Research Centre, Tokyo. -	- -
LHI	Institute of Telecommunication Engineers Award, Best paper award in Radio Astronomy, Fellow IAS, Invited member of New York Academy of Sciences	Fellow National Academy of Sciences Fellow of Acoustic Society of India, Indian Academy of medical Physics, Fellow Indian Society for Malaria and communicable Diseases, Fellow Int. Assoc. for the study of pain, Best Teaching Asst. award (Florida)	DANIDA Fell Member, Mid Atmospheric Programme

some senior professors, even internationally. They are also members of committees empowered to sanction funds and hence obtaining national grants (from the funding agencies) is not of much consequence for them. However, they have not mentioned any foreign funding for their research.

The professors of Delhi, on the other hand, have received awards of a mixed nature. They range from a Best Paper Award to being a member of the New York Academy of Sciences. In this context, a few respondents have remarked that rewards or awards are not real measures of recognition or credibility, as they are due to personal contacts many a time and are therefore hardly objective criteria of one's academic recognition. One professor went to the extent of saying that respect by old students is the greatest award, for no award can be meaningful if students abuse the teachers. However, some were of the opinion that citations are an objective measure of recognition, while another felt that reprint requests in this age of xerox facilities can serve as a measure of one's recognition (and importance of one's work). In contrast, we find some readers of the same department have obtained a number of awards as mentioned in Table 7.1. But on further analysis, we find that these are primarily those of two readers who are treated as marginal members of the department. They are isolates and their research work is generally looked down by others with scepticism. However, all the members of this department are active in their own framework and a couple of

them have wide publicity about their research in national newspapers.

One may conclude by referring to the opinion of a junior respondent. He held that 'modern scientists' lay a lot of emphasis on rewards and recognition, and that various prizes have been instituted to improve the quality of research papers. However, the quality of papers varies enormously. As a result, there does not exist a comparable 'national standard' of rewards, acceptable and valued by scientists working in various kinds of scientific institutions.

We now proceed to discuss the following aspects in order to understand the visibility of our scientists in some detail.

i) Chairing sessions in conferences,

ii) Holding of official positions in associations, academic bodies, scientific societies, etc.

iii) Membership in national, international committees, and

iv) Placement of students.

7.2 CONFERENCES CONVENED AND SESSIONS CHAIRED

Analysis of data shows that chairing sessions is more frequent for the Delhi respondents. It is in this department that we have found instances of faculty at all levels - professors, readers and lecturers - who have had the opportunity to chair sessions in different types of conferences. In all the other departments, the general trend is that only professors (if

not the senior professors alone) are invited to give talks or chair sessions in conferences. This is true of both more research-oriented and less research-oriented departments of the study.

The question now is : In what kind of conferences/seminars/ symposia do the respondents chair sessions : national or international? If the latter, whether held in India or abroad? We find that, respondents from the three Madras departments have chaired sessions in conferences at the state level, national level as well as international conferences held in India. However, some senior professors of Madras have chaired sessions outside the country too. Some Baroda scientists have chaired sessions primarily in those conferences held at the state level only. But for the respondents from Bangalore and Delhi, chairing sessions both within the country and outside seems to be a regular activity although with a difference. It depends on the kind of research collaboration/contacts these departments have within India and abroad.

An interesting contrast has been noted between Delhi and Madras A on the one hand and the rest on the other; whereas faculty of all cadres of the former have chaired sessions in conferences, only the senior faculty of the latter have done so. It may be worthwhile to find out where these conferences were organised in order to achieve some understanding of this difference. Respondents of Madras A and Delhi regularly organise

conferences, symposia, refresher schools etc., in their respective fields of specialisation. It was pointed out by many respondents that this adds significantly to their bio-data when they are evaluated for promotion, considered for election as Fellows to scientific associations or for membership of important committees. When such an event is organised in a campus, the tendency has often been to get departmental colleagues to chair sessions, act as members of the organising committee, as convenors, co-convenors etc. This, to some extent, accounts for the larger number of sessions chaired by the respondents of Delhi and Madras A.

The question now is why is it that Delhi and Madras A organise seminars, conferences etc., whereas Bangalore does not? The answer seems to be that Bangalore is highly research oriented, and the faculty have well directed research contacts both nationally and internationally. Therefore, holding national conferences for academic interaction and to bring people together is not necessary for them. The opportunities for necessary academic interaction are abundantly available within the department. This is so, especially when the department thinks it is doing the best work in the relevant field in the country. Holding international conferences is too much of a problem and is unnecessary because the desired academic benefits are being obtained by regular visits abroad. On the other hand, most of the members get invited to present papers, participate and chair

sessions when the conferences and seminars are organised elsewhere.

Delhi and Madras A are different from Bangalore in that their faculty members do not have the kind of 'visibility' that Bangalore has, although the faculty are highly research oriented. They do not engage in research as a group as do the faculty of Bangalore. Under these circumstances it does become necessary for faculty to organise conferences so that they can interact with scientists working elsewhere in their fields. Being organisers they are also able to increase their visibility.

However, organising conferences is partly a matter of resources that the organiser can funnel and this in turn depends to some extent on the contacts the organisers have.

7.3 RESPONDENTS AND OFFICIAL POSITIONS IN ASSOCIATIONS

The most popular association in physics among our respondents is the Indian Physics Association (IPA). With headquarters in Bombay, it has chapters all over the country. The IPA has members in all departments except Bangalore. Hence holding positions such as secretaryship or presidentship in this association is local. For some, it is merely a formality and they only marginally relate to the activities of this association. One respondent remarked that efforts were made to bring the college teachers together, but there was poor response. However, the respondents of Baroda, where the IPA is

an active chapter, mentioned with some pride that they had held positions like those of president or vice president of IPA. Two other general bodies of physics and general science are, the Indian Physical Society and the Tamil Nadu Academy of Sciences. However, the respondents do not hold positions in these associations very seriously.

Besides the above associations there are some specialised science organisations. Excluding the three departments, X and Y of Baroda and B of Madras, only professors among our respondents have held or are holding official positions in specialised science bodies. Some of these associations along with membership of respondents of different departments are as follows:

Madras (A) - Indian Bio-physics Society
- National Information Centre for Crystallography

Madras (C) - Southern Regional Council of Cryogenics

Bangalore - Society of Biological Chemists of India
- Society of Biological Scientists of India

Delhi - Plasma Science Society
- Indian Astronomical Society
- International Astronomical Union

Scientists of these departments are members of the above mentioned specialised bodies for they are engaged in research which is promoted by these associations. Hence their attitude to positions in these bodies is one of pride. Even those who have not actually held positions, expressed their desire as: "I have

not held any position but certainly I do wish to hold some position in the Bio-physics Society or the Biological Chemists of India". They believe that it amounts to a recognition of their credibility, since these are active organisations. An official position would give them a chance to steer the activities of the association. Further, it would give them an opportunity to interact fairly closely with senior scholars in the field. Again, for the young and ambitious of the group it would be an opportunity to impress the seniors which may benefit them sometime in their careers.

It is relevant to point out a few observations before we close this discussion. Although many of our respondents have been members of foreign organisations of physicists, no one has held any official position in them. Some respondents of Baroda and Madras B have held positions in general science movements such as the Marathi Vigyan Parishad and the PPST. These are voluntary bodies of like-minded people and one needs conviction to become a member. Hence any official position held is taken seriously and activities are enthusiastically initiated and pursued.

7.4 MEMBERSHIP IN COMMITTEES AND CRITERIA INVOLVED - REACTIONS OF RESPONDENTS

Committees are of various kinds and at different levels of importance. They range from Board of Studies of colleges and university departments that decide course structure, syllabi

etc., to national level committees of governmental funding agencies that decide the direction of scientific research. Membership of committees, whatever the nature, is therefore extremely significant as it is not only a measure of recognition for scientists but also crucial to the development of science in the country.

Looking first at the number of faculty involved in committees across the seven departments as shown in Table 7.2, we find that except for Baroda Y and Madras B where it is 25% or slightly less, in all other departments 50% of the respondents are members of committees, with Delhi having the maximum number (18 out of 24 respondents). However, there are differences in the nature of committees and the extent of their influence.

There is one important factor that has to be noted, before we begin a discussion on the nature of committee membership. By and large, the faculty at all levels -- professors, readers and lecturers -- across all departments are involved in some committee or the other,in accordance with their circle of contacts and academic interests. This only indicates that seniority or experience is not the sole factor that determines committee membership. Therefore, the whole issue needs to be looked at more closely. Even a cursory glance at the nature of committees and panels that figure in the responses, would give an idea of the differences beween the departments.

From Table 7.2, the following inferences can be made:

(1) The 'visibility' of the Baroda respondents is confined to the state of Gujarat. It extends to the whole of South India for the Madras respondents, to the entire country for the Bangalore physicists, and is confined to Delhi and the northern belt for the Delhi respondents.

(2) Membership of selection committees seems to be the most common form of committee membership. While it is largely limited to universities, research institutions and scientific laboratories for the Madras and Bangalore respondents, it extends to ministries and other governmental research bodies like DRDO (Defence Research and Development Organisation) and the Electronics Commission for the Delhi respondents.

(3) Membership of crucial committees that are involved in the distribution of funds is minimal for the Madras respondents and restricted to Madras A scientists. It is very selective (in key capacities) for the Bangalore respondents, but mixed and varied for the Delhi respondents.

But what are the criteria that are used to determine membership of such committees in the opinion of our respondents? These range from purely academic to totally extra-academic factors.

One's credibility and academic standing established through one's research output could perhaps be the criterion as the Bangalore respondents put it. 'Visibility' on the other hand

TABLE 7.2

TYPES OF COMMITTEES AND MEMBERSHIP OF RESPONDENTS

/ERSITIES	TOTAL FAC.	NO. IN COMM.	PROFE-SSORS	READERS	LECT-URERS	External Examiners Board of studies of Colleges, Universities and Governing body of universities	On selection panels	Member of Committees in Funding Agencies	On panels to referee projects
ODA (X)	14	6	3	2	1	Universities in Gujarat	Univs. in Gujarat, Colleges and schools in Baroda	DST	-
(Y)	12	2	2	0	0	Universities in Gujarat	Univs. in Gujarat, CSIR Laboratories and IIT-Bombay, Kharagpur	-	-
RAS (A)	13	7	4	2	1	Board of Studies. nearby universities, Ph.D. viva all over the country	Research Institutes, Universities in South India, CSIR Labs. and UPSC.	Member Advisory, Commitee for National Information Centre for Crystallography, UGC panel for Bio-physics.	CSIR, DST,ICAF
(B)	9	2	2	0	0	Universities in South	Universities in South, City Colleges and UPSC	-	-
(C)	6	3	2	1	0	Examination Board to Universities in Tamil Nadu	Universities in the South, TNPSC, UPSC and Defence Labs.	-	-
NGALORE	9	5	4	1	0	-	Universities in the South, SCIR Labs, UPSC and Research Insts.	Several Committees of CSIR,Panels of DST, INSA, IAS, National Bio-Technology Board and National Inst. of Immunology	DST,UGC,CSIR, INSA etc.
LHI	24	18	13	5	0	Colleges in Delhi and Governing body of few Universities around, external examiner for Ph.D. viva to IITs, and universities	College in Delhi, CSIR labs, Res. Institutes,IITs, Universities - Punjab, BHU,Agra, Gwalior,Aligarh. Allahabad,Rohtak, Jammu,Chandigarh, Lucknow,etc. CSIR-Pool Officer scheme, Home Min. DRDO and Electronics Commission	UGC-evaluation panel, INSA-specialised areas Committees, National Council of Science Museums, UGC-book writing, NCERT, Government of India agencies	-

could also be due to a scientist's institutional affiliation. There are at least two types of identity in academics: (a) individual and (b) institutional.

(a) When an individual is a well established scientist and has gained recognition through his contributions, whichever institution he may be in -- an ordinary regional university or an advanced research institution -- 'visibility' comes to him and to the institution for which he works, due to his academic credibility.

(b) When an institution or a department is built by an eminent person or a group of established and enterprising scientists, and over a period of time becomes widely acknowledged as one that attracts the 'best' or the 'cream' of the country, then one derives one's identity by working in such an institution (for example TIFR).

These 'visible' scientists are drawn into committees and panels that at times turn out to be more bureaucratic than academic. Our respondents have, out of experience, foresee the consequences of such membership. While they feel that such membership is extremely crucial for the growth of science in the country, they are aware that it can reduce an active scientist to a professional administrator. Our respondents are apprehensive that such positions may also be used to suppress creative scientists if viewed as threats by the 'visible' scientists. They feel that once a scientist becomes a professional

administrator, he has to give up active academics. To elaborate in the words of a respondent "For example Menon and Yashpal gave up teaching and research long back, but one should have no grudge if they turn out to be really good and dynamic science administrators".

Some respondents, largely from Baroda, are of the view that certain positions such as headship of departments or professorship in university departments gives them some 'visibility', which makes them eligible for membership in committees. Their only apprehension is that, if an incompetent person occupies such a position, it may lead to a series of undesirable consequences.

In the same way, belonging to a well reputed department or institution may automatically place a scientist in committees and panels, for it is assumed that every member of that department is probably one of the best in his area. However, this is possible only when the senior faculty of the department nominates or recommends the names of juniors. Such membership practices were found in Bangalore, where seniors do step aside and encourage junior faculty to take active interest in such committees. If one recalls the compositional structure of this department, one finds that six out of the 9 respondents are professors. But Table 7.2 shows that even readers and assistant professors are members of committees in this department. It may then be noted

that this department is the one that is highly 'visible' among the seven departments of our study.

Some of our respondents across departments feel that although some 'academic standing' is necessary, it is not a sufficient condition for membership in committees. It is only those having contacts with the right persons empowered to place them on such committees who become <u>members of committees or panels</u> of any kind. However, some university administrators express the view that due to financial constraints, experts especially for selection committees are called from nearby institutions. This, the respondents feel is not entirely true. When the Vice-Chancellor or the head is a powerful person, where the candidates to be selected are pre-decided more docile experts are preferred, as such experts will certainly not be trouble-makers. The experience of one of our respondents is illustrative in this respect. He was invited to work on a selection committee as an expert, but the moment he settled in the guest house of the university, he was met by the Vice Chancellor, who told him that, as it had already been decided as to which candidates were to be selected, he need not attend the selection meeting, but could relax and just give his signature when the formalities were over.

Some respondents are of the opinion that academic standing is not essential at all for committee membership. What is necessary is just contacts. This perception has probably made a

number of respondents very bitter about their evaluation panels for promotion. Regarding contacts they feel that, personal friendship with senior scientists or other 'big-wigs' in the administrative bureaucracy, through common club memberships etc., help them to become members of academic and scientific committees. Educational background at times becomes very relevant. One may have school and college friends employed in different government agencies, or one may have been a student of a well-known scientist or well-connected scientist. What matters is "who recommends you" to quote a respondent. Some feel that junior scientists of the same laboratory at times get these positions while seniors do not, which definitely implies connections of the 'right kind'. A junior respondent reacted very strongly by saying "scientists these days spend more time on telephones and at airports, than with their students" suggesting that they are all the time either making new contacts or renewing the old ones.

The above discussion highlights the fact that academic credibility is not the sole determining factor for membership in committees. Contacts play a very significant role. This leads us to ask questions such as the following: How do our scientists operate, when they become members of such committees? Do considerations under which they gained membership have any bearing on their functioning? How do they use their power and

what consequences does it have for the growth of science in India?

7.5 COMMITEE MEMBERSHIP AND POWER POLITICS

It would probably not be out of place here to refer to the typologies that have been suggested by some scholars, while studying politics in science and the Indian scientific community. Ward Morehouse (1976) in his analysis has used C.P. Snow's identification of three forms of closed politics. These being, 'committee politics', 'hierarchical politics' and 'court politics'. 'Committee politics' refers to the largely internal phenomenon of the dynamics within the organisational system for research and development. 'hierarchical politics' refers to a chain of commands that could be a mixture of internal and external phenomena and 'court politics' refers to the attempts to exert power through a man in whom there is a concentration of power and thus is largely external.

However, his attempt is to relate the politics of the professional establishment to the political system of the country, and thus account for the poor quality of science in India. He has emphasised that Snow's categories fit the Indian scientific scene only approximately and not exactly.

The major weaknesses of committees as instruments for decision-making in Indian science affairs, according to Morehouse are : (1) infrequent meetings (2) too long an agenda for

meaningful discussion, for example, the meeting of a technical committee for allocating funds for research projects may last only a day and a half, during which time decisions on some 200 to 250 research proposals are taken (3) the same people are members of many important committees, and the number of such people is very small. For example, some scientists are members of as many as 50 committees. Morehouse views these committees as being used for many other purposes such as getting people jobs, fellowships, financial support for research projects and the like and thus do not function objectively (Morehouse, 1976:70).

'Hierarchical politics' refers to the inevitable consequence of increasing bureaucratisation of science. As a large proportion of the scientific activity is supported by the government, it is expected that bureaucratic patterns of organisation will tend to influence scientific institutions in the country. Morehouse goes on to add that this gives rise to 'hierarchical politics' which may be enhanced by strategies of conflict resolution. For instance, a conflict between two scientists who are part of the same hierarchical system is not resolved within the scientific institution, but at times is resolved at the highest political/bureaucratic level, totally outside the institution.

The third form of politics is 'court politics', i.e., excessive domination of the bureaucracy and the relative inability of the scientists to tackle it. In Morehouse's view,

this is what ails Indian science to a large extent. He therefore, advocates dissociation of the academic professionals from the clutches of the political leaders and the political system and from the administrative bureaucrats. Several others, besides Morehouse, have also highlighted this factor. (Rudolph and Rudolph 1972; Dedijer 1963).

There has been some concern among scientists, educationists etc.,in the recent past to unravel the politics in science within the boundaries of the academic community [Pichare 1987; Govindarajulu 1985]. The consequences of 'committee politics' would therefore refer to partiality in sanctioning funds for projects, preventing competent or aspiring scientists from getting any benefits, cornering of travel grants, exchange fellowships and other beneficial programmes by a select few through inadequate advertisement or circulation of information.

During field work, we came across many respondents not belonging to Delhi , who complained that they did not even get to know about UGC exchange programmes. Even when the relevant circular is received, it is so late that there is hardly any time to apply. The feeling was so strong that when the UGC Chairman visited Madras on some occasion, the University Teachers Association submitted a memorandum demanding the setting up of a UGC regional Centre in South India.

To discuss such aspects we turn to membership of our respondents in committees that directly or indirectly relate to

the growth of science in India. These include selection, evaluation panels, national committees of funding agencies, committees directly related to science policy etc.. In these respects two departments emerge clearly as the most significant i.e., Bangalore and Delhi. The Bangalore respondents have membership in key bodies and are in key positions. However, they take little interest in these committees. If they do accept these positions it seems only to ensure that their share of funds and facilities are obtained regularly. Some Delhi respondents are also members of such committees. Their close proximity to all these agencies seems an important factor in determining their membership in them.

When a few individuals become members in several such bodies, it leads to the formation of a closed circle of academic elites enjoying the benefits of concentration of power. However, the most important consequence of 'committee politics', is to be seen in selections of whatever kind: of new faculty for university science departments, of faculty for promotions, of Fellows to prestigious associations, and the like. Through fresh recruits and selections, the continuity of scientific activity is ensured. If criteria other than academic credibility play a key role, then it may so happen that scientists in the future may spend more time and energy in playing games within the profession than engaging in active research of any kind.

7.6 COMMITTEE POLITICS, RECRUITMENT AND PLACEMENT OF STUDENTS

In response to our question about the criteria used for the selection of new faculty and the pattern of recruitment, opinions ranged from merit being the sole criterion to absolute favouritism being the deciding factor. Bangalore and Madras B respondents feel that merit is the main deciding factor. However, there is a difference in their interpretation. For Bangalore, the research goals of the department constitute the key factor. If the need for a particular specialisation is felt, then there is a search for the best candidate in that area. Through informal correspondence with their friends, they identify such candidates, call them over to give seminars, discussions and thus in some sense the selection is almost over before it is formalised through advertisement and interview. If in this process, their own students get in, they say that it is only an accident, for at times, their own students may be the best trained in the country in the relevant area. Recruitment is therefore, 'directed' and 'objective' in their opinion. However, they say that this is not the case in all the departments of the same institution, for much depends on the Chairman of the department and the interests of the group.

Respondents of Madras B clearly state that selections have always been fair. There is no question of in-breeding and while they do have a system of writing to institutions for recruitment purposes, it is not regular or systematic. But the decision of

the selection committee is final. One respondent narrated his experience of finding a job in Madras B. He had returned from the U.S. and was looking for a job in India. He accidentally met the head of the department of Madras B. On enquiry our respondent was told that advertisements would be appearing shortly, but they did have someone in view. Yet he was encouraged to apply, as the candidate was likely to go abroad for three years and hence he might be selected as a substitute for that period. The respondent went ahead and attended the interview and was selected for the permanent position straightaway. He later learnt that the Vice-Chancellor and the experts were all favourably disposed towards him and that the head accepted their decision although it was against his wishes.

The respondents of Madras A and C observe that almost equal weightage is generally given to merit and social connections. In-breeding did exist in the earlier years of the departments and it was justified on the ground that the aim was to build a good research group. Since there were not many qualified candidates available at that time and as students trained in better institutions did not wish to come to Madras (for example students of TIFR), there was very little option. However, with years and changes in university policy such as the strict imposition of reservations, interference of politicians and the changing perspectives of different Vice-Chancellors, the powers of department heads have weakened. It has also resulted in the

breakdown of the group, as recruitment in specialised areas for building a team is no more followed. The addition of faculty even with diverse research interests on grounds of reservation policy seems dominant in recruitment pattern.

The political upheavel in Tamil Nadu in the mid 1960's resulted in the fall of the Congress Party and the rise of a regional political party, Dravida Munnetra Kazhakam (DMK) to power. As the new government believed that preference for all jobs till then was given to Brahmins, a compulsory quota system was introduced. Education was in no way exempted. The non-Brahmin respondents of our sample are happy with the present situation as they feel that it is only fair that they are given a chance and hope that reservation policy would be strictly adhered to. However, there seems to be constant tension between these two groups, the Brahmins and the non-Brahmins.

While this aspect of reservation was frequently mentioned by some respondents of Madras A and mildly put forth by Madras C, it did not seem to affect the respondents of Madras B. It is to be noted that Madras A,B and C belong to the same university, but they are specialised and independent departments. Madras B is the Theoretical physics department. It was learnt that there are fewer candidates specialising in theoretical physics than in experimental physics and among the former category very few local non-Brahmin candidates are available. This situation arises partly because theoretical physics as a doctoral programme is

mostly offered by Advanced Research Institutes and very few universities. Selection of students in them is on an all-India basis and through rigorous open competition. As a result very few qualified local candidates are available.

Next come the Delhi respondents whose opinions on recruitment were largely mixed. However, many feel that external pressures do play a significant role. Unlike the respondents of Madras A and C, those of Delhi seemed unhappy with even their heads of departments. These heads, our respondents say, are interested not only to place their own students, but at times wish to favour some outsiders for personal reasons. Hence objectivity and academic credibility suffer. Some observed that a central minister's nephew was taken in a department as it was felt that one could always benefit from his political connections. They also feel that often panel members bargain unscrupulously and strike a compromise. However, they say that fortunately this situation does not always obtain for all departments, since a powerful and right thinking head (committed to academic values and growth of the department) makes a difference. The system of rotation of headship and democracy within departments helps in checking the influence of politicians and bureaucrats.

The respondents of Baroda maintain that in Baroda there exists a clear preference for their own students. One may call it 'in-breeding', but a senior faculty reacted strongly to this

charge by saying 'what is wrong with it? Who will take our students? After all every university has its students too'. It was learnt that even UGC norms have been relaxed to favour some candidates. However, the respondents say that this is the situation for recruitment only at the lower levels, but for senior positions, merit is the primary consideration. As for political pressure, they say that it does exist, but direct pressure is minimum. At times, appointments may be delayed, but the decisions of the selection committee are not overruled. The views, disposition and personality of the head are crucial in selections.

A clear understanding of the situation emerges when we look at the employment patterns of the students. Table 7.3 shows that the Baroda students have not been able to get jobs outside their state. The Madras students do at times get jobs outside Tamil Nadu, but only within the southern states of the country. Not many Bangalore students seek jobs; and when they do, many prefer jobs in advanced research institutes. The data for Delhi yield striking facts. The greatest number of students of Delhi have been placed in city colleges affiliated to the same university. The remaining, ignoring the foreign students, are placed in universities and research institutes of all kinds.

It may be recalled that Baroda respondents are hardly members of national level committees. Their 'visibility' is restricted to the state. Some Madras respondents do have

PLACEMENT OF STUDENTS

UNIVERSITIES		POST-DOCTORAL WORK		EMPLOYMENT	TOTAL
BARODA (X)	2	PRL, Ahmedabad USA	20	MSU - 8 Univs. in Gujarat-6 AIIMS, Delhi-1 Industries, Baroda-2 Colleges-2 Govt. Deptt.-1	22
(Y)	4	USA	12	Univs. in Gujarat-6 Industries-5 College-1	16
MADRAS (A)	22	USA - SUNY, Columbia, Illinois, Texas, Br. Columbia, Purdue and Netherlands, AIIMS, Delhi	7	Madras Univ.-4 Textile Res., S. India-1 Univ.in T.Nadu-1 Govt. Project-1	29
(B)	5	Manchester, Iowa, SUNY-US Same department	8	Colleges in city-4 College in T.Nadu-1 Same department-1 Univs. in South-1 BHEL Res.Scientist-1	13
(C)	1	Rochester	11	Univs. T. Nadu-2 Same department-5 Colleges in City and outside-3 Industries-1	12
BANGALORE	19	Canada-1 USA-14 UK-1 Germany-1 Same department-2	5	Same department-1 Mysore Univ.-1 CSIR Lab.-1 TIFR-1 Inst.of Immuno- logy-1	24
DELHI	12	Belfast,Univs in Canada, Denmark-6 PRL-1 NPL-1 CSIR Lab.-1 Same department-1 SPL(Defence Lab)-1	78	Colleges in Delhi-44 NPL-2 Colleges outside Delhi-5 Foreign students(went back to country)-4 Same Univ.Deptt.-5 Industry-1 Other Univs.-3 Engg. College-1 Private Res. Inst.-2 Defence Labs.-3 BEL,Bangalore-1 SAIL-1 PRL-1 Computer firms-3 DOE-1 CSIR Pool Officer-1	90
Total	65		141		206

membership in such committees but their area of 'effective contacts' are limited mainly to South India. The Bangalore respondents occupy key positions in important national level Committees but hardly ever participate in university selections. The Delhi respondents reveal an absolute mixture of committee membership and contacts at all levels: from central ministries to their own university colleges.

There is sufficient correlation between committee membership of respondents and the placement of their students. Those from Baroda remain in Gujarat, those from Madras in Tamil Nadu and the neighbouring states, the Bangalore students go to advanced research institutes and the Delhi students are widely dispersed all over the country besides those located in Delhi colleges.

All these indicate some influence of 'committee politics'. One welcome consequence of this perhaps is that 'visibility' of scientists outside their state has reduced in-breeding to some extent. In a sense, it is in contrast to the educational background and career profile of our respondents. More than 50% of them were students of the same department where they were working. But their students are not automatically recruited as faculty members to the same department.

As for students going for post-doctoral work, we have evidence for such patterns in all departments. But we find that in two departments - Madras A and Bangalore, the incidence of

post-doctoral fellowships abroad are much higher than those seeking employment. Given the nature of research problems it is understood that there is high demand for well trained candidates in frontier areas outside the country. Secondly, in line with our earlier inferences, external contacts of both these departments are regular, though individual based and diffused for Madras, and directed and institutional for Bangalore. These two factors enhance the probability of acquiring post-doctoral position for their students both outside and within the country. It may be relevant to recall a remark of a Bangalore respondent: He said, "we purposely encourage our students to go abroad so that they do not develop an inferiority complex about research work in India and are confident to work independently on their return. Besides, it provides them the necessary academic exposure".

An analysis of the nature of 'visibility' or recognition of our scientists was the main concern of this chapter. Several indicators of recognition were used for this purpose. Awards, rewards obtained by scientists; official positions held in scientific societies and membership of Committees related to science/education policy of the country were looked into in detail. Our inferences show that 'visibility' of scientists is not always in consonance with their academic credibility as understood in the traditional framework of stratification in science. Extra-academic linkages with the science bureaucracy or

the administrative bureaucracy both at the national and local levels have brought 'visibility' to some scientists. However, this 'visibility' whether based on academic credibility or extra-academic linkages or a combination of the two are important as they draw these scientists to positions of 'power' within the bureaucracy of science.

It is in this sense that the role of 'visible' scientists becomes crucial as they direct the very nature of development of modern science. Our findings show in some detail as to how our 'visible' scientists wield this power. The overall inference one draws is that the dynamics of power in science within the country is characterised often by extra-academic and personal factors than those that are purely academic and objective. We would elaborate on this aspect of types of 'visibility' and its relation to 'power' in the following concluding chapter of the thesis.

CHAPTER VIII

STRATIFICATION IN SCIENCE: SOME CONCLUDING OBSERVATIONS

The main aim of this endeavour is to understand the dynamics of science in India through a study of its scientific community. Scientific community is a notion that has been ambiguously used in the literature. Its reference ranges from a large group consisting of all the scientists of a country (a national scientific community) to a small group consisting of the members of a single research specialisation. Merton viewed the scientific community as a single entity where integration exists as a result of a consensus about certain strategic norms and standards for the pursuit of science (disinterestedness, universalism, organised scepticism and communism). Research within this framework consequently focused on communication patterns, aspects of recognition and distribution of rewards to the scientists in consonance with these norms. Investigations thus justified the stratification that arose among the scientists owing to the unequal distribution of rewards and resources. However, Merton's norms did not allow for variations that could and do arise across disciplines and scientific specialisations.

Kuhn's model of 'paradigm shifts' enabled sociologists of science to delineate boundaries of the scientific community. It referred to scientists who owed allegiance to a 'paradigm'. Thus work on the scientific community within this framework

concentrated on the social organisation of research areas. However, quantitative or bibliographic data culled from the research productivity records of scientists were mainly used to understand communication patterns among them and the effect of this communication on the cumulative growth of knowledge. The failure of formal established communication patterns to explain the complex dynamics of interaction amongst the members of a scientific community demonstrates the limitation of this approach.

It should be noted that both these models have used the concept of scientific community to refer to a homogenous whole. It is this notion of a scientific community that Karin Knorr rejects. She is of the view that the research process involves a number of 'selections' from available equipment, material, technique, results obtained and their interpretation by the researcher. Such selections are not always governed by fixed rules within a monistic framework and are not in accordance with a set of locally recognised standards. Scientists on the other hand have 'resource relationships' with fellow scientists of various specialisations, with government officials, university administrators and other bureaucrats who may significantly affect the form and content of the research projects. She therefore advocates in depth investigations of the process of knowledge-production before making macro-level generalisations based on the knowlege produced. As expected, studies on scientific community

within this perspective are detailed ethnomethodological case study analyses of small research laboratories or closely knit groups of scientists working on similar research problems.

Studies on scientific community in India have been few and sporadic. There are studies devoted to stratification in science in India no doubt, but no particular framework has been exhaustively used in these studies. This may probably be due to the difficulty involved in identifying a scientific community in India in either the Mertonian or the Kuhnian framework. Scientists here work in different types of scientific institutions which impose varied duties and obligations on them. However, the major focus of scientific community studies has been on the successful scientists of 'Big Science', who work in advanced research institutes of the country. The large majority of the remaining scientists are generally categorised as doing mediocre science. Factors such as parochial values, influence of local political system and misguided priorities of scientists (that takes them away from research in Big Science) are often identified as causing this mediocrity. As a result, very little communication is found to exist between these two groups of scientists which gives rise to fragmentation in science. Besides, the scientists in the country are also portrayed as lacking a common set of values and priorities concerning teaching and research. This fragmentation in turn is identified as the cause of the overall mediocrity in science in the country.

Our study has attempted to understand the nature of this fragmentation at the institutional level, unlike earlier studies which focused on career patterns of individual scientists. Scientists from one kind of institution, i.e. the universities, have been studied. Among university scientists, physicists have been chosen for this purpose as physics is among the oldest science disciplines and as almost every university in the country has a department of physics. Inadequate explanations of the fragmentation within the scientific community led us to believe that professional linkages which characterise 'communities' of scientists in advanced countries may not be as significant as those in countries doing peripheral science. Our main interest therefore has been the informal academic and extra-academic linkages among scientists, and we have attempted to show how these linkages determine the visibility of scientists.

Our study shows that the history of the departments and the organisational goals of the institutions in which these departments have been located significantly affect the nature of linkages scientists establish with the rest of the scientific community. Besides it is also evident that these linkages have an important role in the eventual 'visibility' that scientists and departments attain. Much seems to have depended on the choice of the head when the department was set up. Where an active researcher with sufficient training and exposure was selected, a tradition has been built up in which meaningful

integration of research and teaching has taken place. This process has been strengthened where and when these leaders have enjoyed the unconditional support of the Vice-chancellors of their respective universities, especially during the initial years of expansion of the departments.

Besides these, the departments which have followed a policy of recruitment directed towards 'group building' within a research specialisation have been successful in doing 'Big Science'. In contrast, in those departments where recruitment patterns are found to be diffuse and undirected, research activity entirely depends on the initiative of individual scientists. Departments of the latter type either have not really taken off in 'Big Science' (and have thus remained peripheral) or are on the decline. However, it has to be pointed out here that recruitment pattern depends largely on the organisational goals of the department. Where teaching is the major obligation, recruitment of faculty members has been in accordance with this requirement, which may seem undirected due to the diffused research interests of the scientists.

Our analysis of the formal and informal interactions of the scientists and their academic and extra-academic linkages within the scientific community and outside leads us to postulate two polar opposites. These extremes specify conditions which may be said to promote 'good science' and 'bad science'. However, these opposites have also highlighted different kinds of

'visibility' and 'power' enjoyed by scientists in the country. The two polar opposites are the Molecular Biophysics Unit (MBU) of Bangalore representing 'good science' and Baroda X representing 'bad science' within the system of stratification based on doing 'Big Science'.

MBU is essentially a research department, its teaching responsibility being extremely low. In contrast, Baroda X is primarily a teaching department, its teaching load being the highest among the seven departments. Scientists of MBU have the highest (way above the next highest) productivity in terms of research papers, while Baroda X has the lowest. Research publications of the scientists of MBU appear in international journals of repute, whereas Baroda X physicists have very few publications in international journals. MBU scientists have won almost every important national award in science, whereas Baroda X physicists have won no such awards. Scientists of MBU sit on all key committees of national science policy, whereas Baroda X physicists sit on local and regional ones.

MBU emerges as an independent centre of physics, cut off from the rest of the scientific community in terms of active research interaction. Its members are highly satisfied with their organisation, infrastructure, intra-unit interaction and research culture. MBU is also recognised among the science circles as one of the best centres of science in the country. Interestingly, Baroda X also emerges as an isolated department,

cut off from the rest of the scientific community. Its members are satisfied with the infrastructural facilities and they find their own academic activities, especially teaching, quite meaningful.

However, both these units, isolated in their own way, have employed different strategies for their growth. MBU presents itself as a highly competitive team at the level of the relevant international community. Their research contacts are directed, regular and systematic, and these are mainly with the leading laboratories of the advanced countries of the west. They do have contacts with scientists working on similar problems within the country, but they rarely collaborate with them. Their academic eminence has brought them 'visibility' and positions of 'power'. They thus occupy the upper rungs within the system of stratification of science in India. In other words, MBU emerges as having an ideal 'culture of science' (democratic and apolitical) which enables its scientists to do 'good science'. MBU scientists therefore are 'visible' in the familiar sense of the term.

In contrast, Baroda X physicists have limited internal interaction with departmental colleagues, as they do not have common research interests. Their external contacts are diffuse and sporadic and depend entirely on individual initiatives. They may represent all features of doing 'bad science' but perform very important functions at the local level. They seek identity

among the teaching and the student communities of the state. They regularly write books and text-books on general science and physics for school and college students in Gujarati which is the local language. They contribute to local journals where they emphasize problems of teaching and suggest various innovative methods. Such themes are given priority in their local conventions. Besides these, they also actively engage themselves in popularising science through people science movements at the regional level. They regard requests by the education department of the state to write text-books as a measure of recognition.

The Baroda X physicists have effective links with the local wealthy who are patrons of the university. Some of them also have contacts with the state level politicians and bureaucrats. These have brought 'visibility' to them at the local and regional levels. They are members of important state level committees that deal with higher education. Thus the Baroda X scientists may be 'invisible' at the national and international levels, but are highly 'visible' at the local and regional levels.

If the MBU scientists are 'visible' in the familiar sense of the term, the Baroda X scientists are 'visible' in a very different sense. Significant and high research productivity brings recognition to the scientists practising 'Big Science' in the form of rewards and awards and this in turn gives them positions of power in the bureaucracy of science; in a word, 'visibility'. Such a model of stratification does not

accommodate any other sense of 'visibility'. Our study in contrast, has brought out aspects of 'visibility' and 'power' peculiar to peripheral science in India, as illustrated by the Baroda X physicists. This notion of 'visibility' unrelated to research productivity may be relevant to study of fragmentation among scientists in other developing countries.

In the rather simplistic model of fragmentation that we have suggested, the two departments - MBU and Baroda X occupy the two extreme positions. The remaining five departments lie somewhere in between, but do not seem to obey a rigid ranking system. Their positions vary when different aspects of stratification are considered.

If one considers the research productivity, we find that the physicists of Madras A occupy the second highest place, next only to the MBU scientists. Their publications too are in international journals of repute. However, research activity in Madras A is highly 'individual-oriented', and hence we find that only a very small number of senior professors have won national level awards. But, the overall recognition received by these professors at the national level is very limited. Their 'visibility' and 'power' are largely regional. In this respect, the Madras A and the Baroda X physicists are rather similar but they do differ in certain ways. The Madras A physicists, unlike those of Baroda X, do not have strong links either with the local wealthy or with the politicians or bureaucrats of the state.

This dissociation from their immediate socio-cultural environment has significantly restricted their 'visibility' even at the local level.

Turning to the nature of the contribution that they make to the larger society, we find that the Delhi and the Baroda X physicists exhibit certain similarities. They write books and text-books on physics and general science for school and college students. But unlike the Baroda X physicists who write in Gujarati, the Delhi physicists (who prepare text-books especially for the National Council for Educational Research and Training) write in English. Some members of the Delhi department are also involved in people science movements. Like the Baroda X physicists, Delhi physicists also have strong links with both the science bureaucracy and administrative bureaucracy at the national level. They occupy key positions in committees of various important funding agencies. Thus, they are as much 'visible' nationally as the MBU scientists, in contrast to the Baroda X physicists who have high 'visibility' only at the local and regional levels. It may be mentioned that the 'visibility' of Delhi physicists seems to depend more on their close relationship with the politicians and bureaucrats, than on their research productivity.

In contrast, Madras C exhibits similarity with the MBU scientists with respect to research activity and research interaction. Their contacts with fellow scientists are directed,

regular and systematic. They regularly keep in touch with leading laboratories within their field outside the country. They do function as a group and regularly publish in journals of international repute. However, as far as recognition is concerned, we find that they have not won any national awards and neither are they members of national level committees. Their 'visibility' is very much local; they are members only of Committees that formulate the educational policy of their own state.

All these differences illustrate the nature of fragmentation and isolation in the scientific community in India and highlights the gaps in the centre-periphery chain even within peripheral science. However, it may be stressed that this centre; i.e., MBU (and the like) and the periphery, i.e., the other universities, are related in certain ways. The large number of state universities, like Baroda X, systematically train students and provide the necessary talent for those advanced research institutes that practice 'Big Science'. Any talent produced is promptly appropriated by the successful scientists of 'Big Science' but what they give in return to the periphery is very minimal. This makes the communication patterns among scientists in the country non-reciprocal and the centre-pheriphery chain highly exploitative.

In our study of the fragmentation among scientists we have found that there are major differences in the organisational

goals of various scientific institutions, and the duties and obligations of the scientists working in them. Such differences have made meaningful communication among scientists extremely difficult. Fragmentation at the institutional level, perpetuated by the science policy of the country, generates fragmentation in the scientific community. For example, the Science Advisory Council to the former Prime Minister suggested that in view of the poor quality of university science, specialised postgraduate programmes in science, engineering and technology be introduced in some national research institutions and that such institutions be given the status of 'deemed universities'.

Similarly, the UGC's policy to improve the quality of science in universities through its programmes such as CAS, DSA etc., have only given rise to further discrimination and differentiation even among university scientists. In such a situation it seems somewhat pointless to emphasize the need for an integrated scientific community with shared goals and values, simply because the science policy of the country does not allow such a 'community' to emerge. There then may be atleast two alternatives : (1) to accept the notion 'communities of scientists' and (2) to redefine the concept 'scientific community' so as to refer to a group of scientists whose institutional affiliation imposes different duties and

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obligations on them as a result of which they cannot function within a universal set of values and norms.

In our study, the two extremes -- Baroda X and MBU, isolated in their own ways, have however been discharging their respective roles effectively. The Baroda X physicists integrate well with the social and political system of their state and fulfil the expectations from a state university. The MBU scientists have gained national recognition owing to their contribution to 'Big Science'. This 'visibility' has given them the power to direct the science policy of the country.

However, it is evident that these successful scientists of 'Big Science' are primarily interested in ensuring the uninterrupted flow of large funds for their research activity. They take little interest in responding to the needs of the society to which they belong. The percolation of the latest knowledge in 'Big Science' to the periphery within the country is very minimal. These scientists show very little interest even in the development of a scientific discourse in the Indian languages. Availability of such a discourse would have facilitated the dissemination of knowledge of 'Big Science' among the students at large. In sum, the condemnation of university science by the elite scientists is highly unjustified.

The elite scientists of 'Big Science' within the country constantly strive for recognition from the 'centres' of international science. Their efforts are therefore consciously

directed towards the perpetuation of 'Big Science' in the few elite institutions of the country. They are blind to the inherently exploitative nature of western science and technology. They produce well-trained graduate students in the institutes of 'Big Science' who are promptly appropriated by the 'centres' of international science. This form of 'brain drain' is reminiscent of the centre-periphery chain that operates within the country.

However, in this process, the elite scientists of 'Big Science' in the country, virtually lose on both fronts: they contribute very little, if at all, to the integrated development of modern science within the country, and in the field of international science only a very few of them receive acclamations and that too once in a while.

It is time then for some serious stock-taking of both our science policy and scientific institutions. A total restructuring of our scientific institutions may be in order, or else 'Big Science' will continue to grow in islands and the gap between the centre and periphery within India will continue to exist, if not widen further. With the current movement towards the promotion of higher education through the regional languages, successive generation of scientists will not only be further cut off from the language of 'international science', but probably become even less communicative with fellow scientists belonging to different states within the country. Fragmentation within the scientific community then is bound to increase. Imperfect

communication in turn may then lead to a consistent fall in standards and the perpetuation of mediocrity. Hence, conscious and deliberate efforts are called for to arrest this trend of increasing fragmentation within the scientific community in India.

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APPENDIX

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

This survey to understand the nature of the scientific community in India, is a part of my doctoral research. Kindly co-operate, the information obtained will be kept in strict confidence.

Prema Rajagopalan

1. a. Name:

   b. Age :   C. Sex:

   d. Present Institution where working:

   e. Designation :

   f. Duration of stay :

2. Educational Background

Degree	Institution/ University	Year spent From	To	Specialization
Masters				
Doctorate				
Post-doctoral				

3. Professional Background

Position	Institution	Years From To	Research Areas
i)			
ii)			
iii)			
iv)			
v)			
vi)			

4. How did you choose your research problem for your Ph.D.? You may tick more than one.

    i) Reading, scanning of literature

    ii) Suggested by supervisor or any other senior faculty member

    iii) Developed an interest in the area even earlier

    iv) By accident

    v) Prestige of the field

    vi) Availability of job if specialized in that area

    vii) Availability of funds for further research

    viii) Availability of experimental facilities

    ix) Any other, specify

5. a. Do you still work in the same area? Yes No

    b. If not, give details of change to new areas and reasons for doing so.

Research areas	Years spent From	To	Reasons for change
i)			
ii)			
iii)			
iv)			

6. a. How many research publications do you have?

   b. Please attach a list of your publications with the following details:

      (i) Journal (Year)   Indian/Foreign   Single authored

      (ii) and if co-authored, then whether

         with guide

         with students

         with colleagues and

      (iii) location of co-authors at the time of publication.

   c. How many books have you published?

      i) general books

      ii) text books

      iii) others, including lecture notes, guides etc.

7. Give details of awards received. This includes fellowships, best paper awards, chairing a session in a conference, special research grants, etc.

Year of receiving the award	Name and Nature of the award
i)	
ii)	
iii)	
iv)	
v)	

8. a. Give details regarding your membership in Professional associations/academies.

Name of the body	Year of initial membership whether continues or discontinued.
i)	
ii)	
iii)	
iv)	

b. How do you view the activities of

i) Indian Science Congress

ii) Indian Academy of Sciences

iii) INSA

iv) Any other, Please specify

9. Identify the type of interaction you have with other scientists.

	Scientists in India	Scientists Abroad	Mention names of institutions where necessary
i) Informal discussions			
ii) Exchange of pre-prints			
iii) Regular correspondence			
iv) Meeting in conferences			
v) Research collaboration within department			
vi) Research collaboration outside department			
vii) Short-term visits to other institutions			
viii) Research collaboration with foreign universities, agencies			
ix) Any other, Specify.			

10. Details of the present institution where working

 a. Number of faculty members working in the same area of research as yours.

b. Is the interaction with your colleagues

i) limited to informal discussions

ii) extends to intensive dialogues

iii) results in joint publications

iv) any other, specify

c. Give the number of teaching hours per week including tutorials and labs.

d. Does teaching

i) Help research - How?

ii) Hinder research - How?

e. How many students

i) have completed Ph.D. under your supervision?

ii) are working under your supervision at present?

f. Do they work

i) in the same area of interest as yours

ii) or in other areas - specify.

g. Do you think that guiding research students is

i) an aid to your own research - how?

ii) an unnecessary burden - how?

iii) any other, specify.

h. Give a break-up of post-doctoral placement of your Ph.D. students with names of institutions.

	Post-doctoral Research	Employment
i)		
ii)		
iii)		
iv)		
v)		

i. Give details of departmental seminar programmes

j. What is the system of recruitment in your institution?

k. What are the criteria for promotion in your institution?

l. Are you satisfied with this system? Give reasons.

m. How are the facilities in your institution

i) with respect to labs

ii) libraries

iii) funds for research

iv) any other, specify

11. List the sources from where you have received funds for research.

12. a. Give details regarding membership in Committess outside your institution (i.e., Board of Studies, National Committees, Consultancy work, Selection Committees, etc.)

b. Give your opinion about the criteria for membership to such Committees, their functioning, etc.

13. What are the problems that you face in your work situation?

14. What is your impression about the scientific community in India?

15. What is the occupational status of your profession in the Society?

16. Any other comments/suggestions.